25 OCTOBER 1957 ... & SIXPENCE

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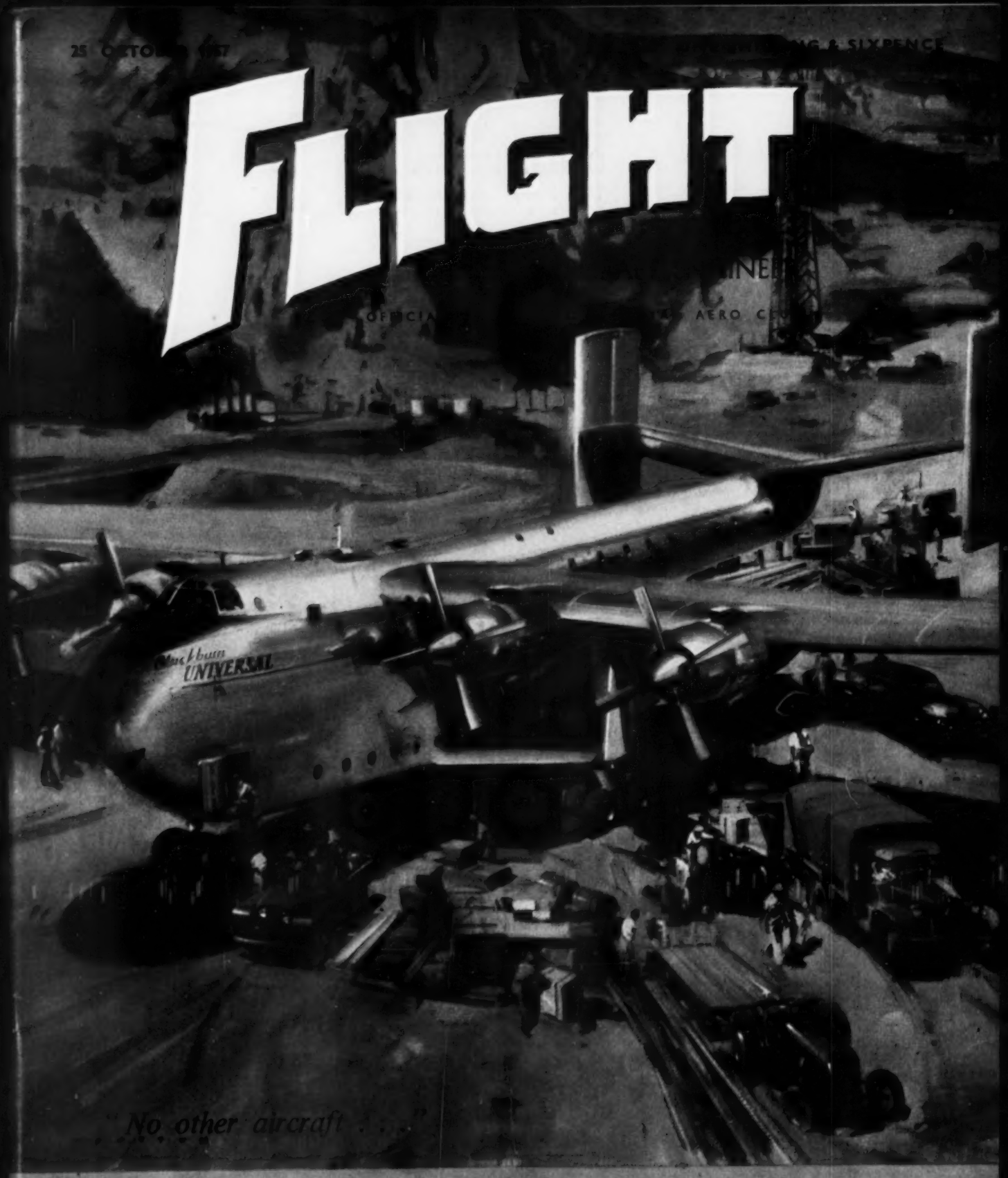

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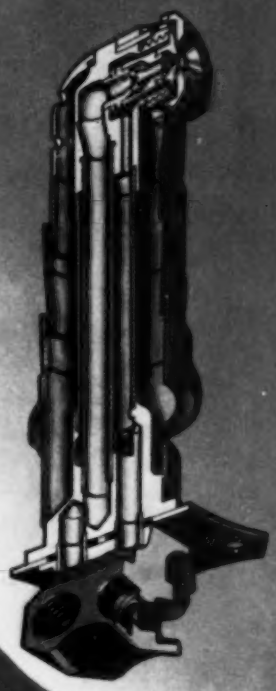

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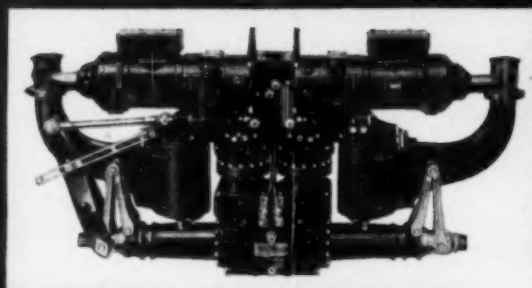

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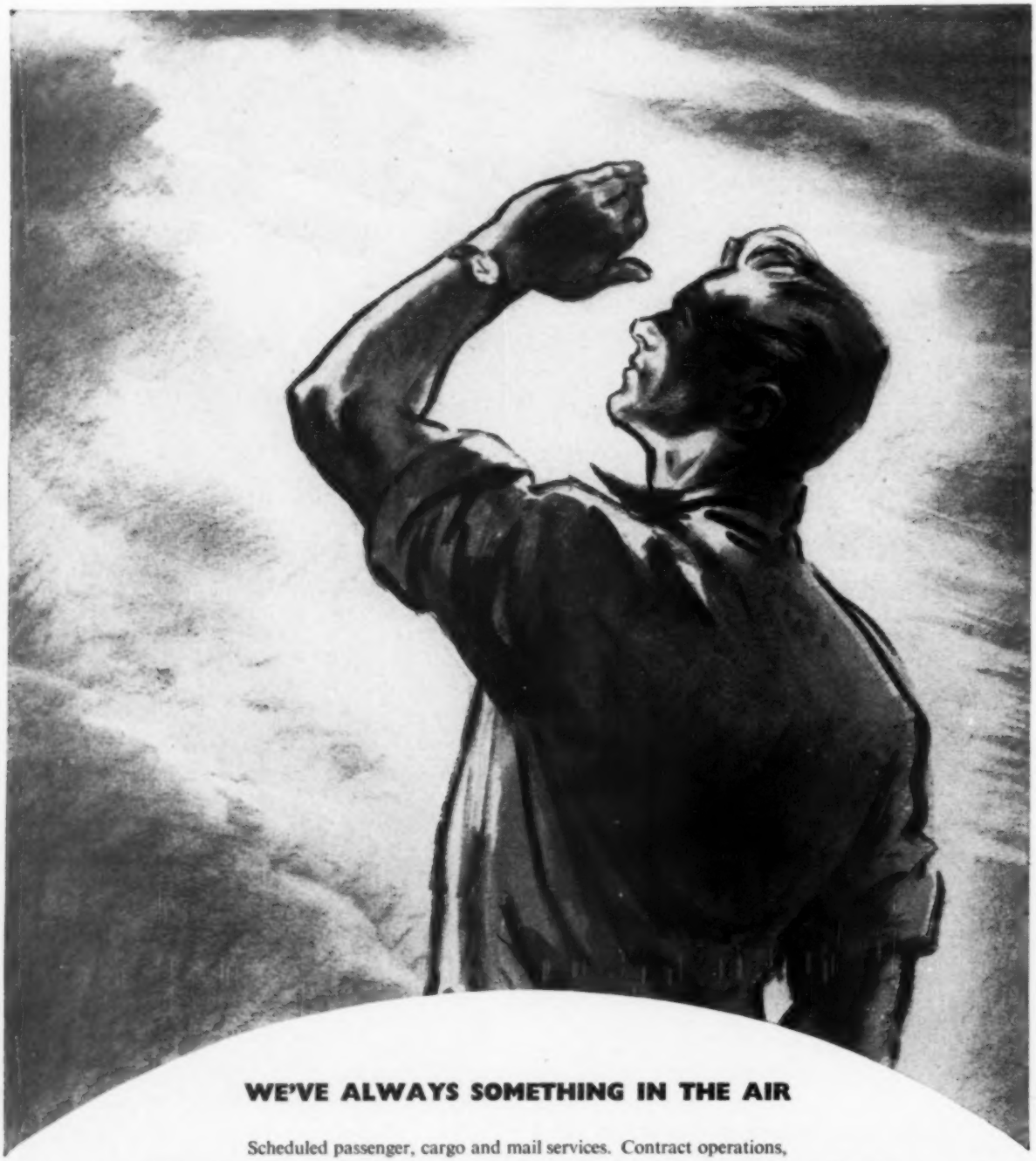

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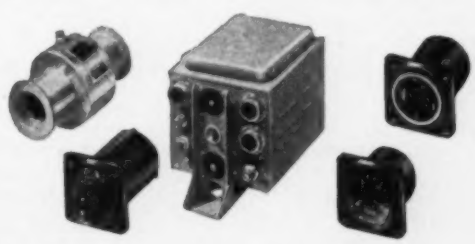

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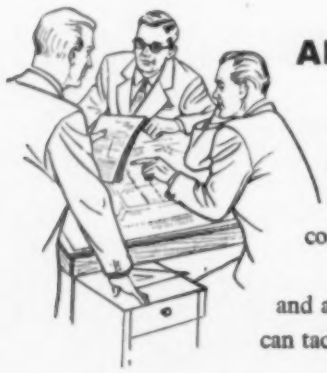

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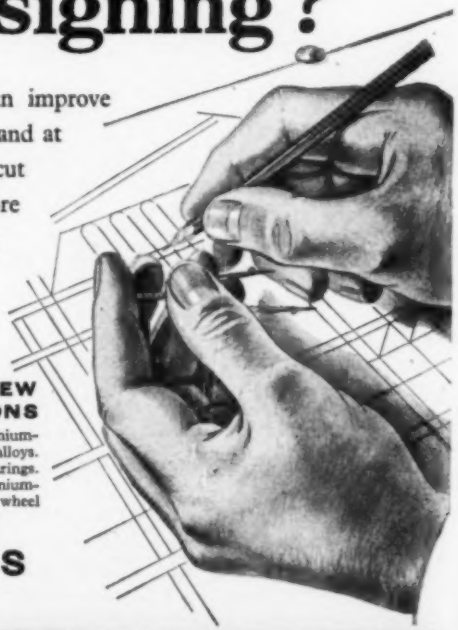

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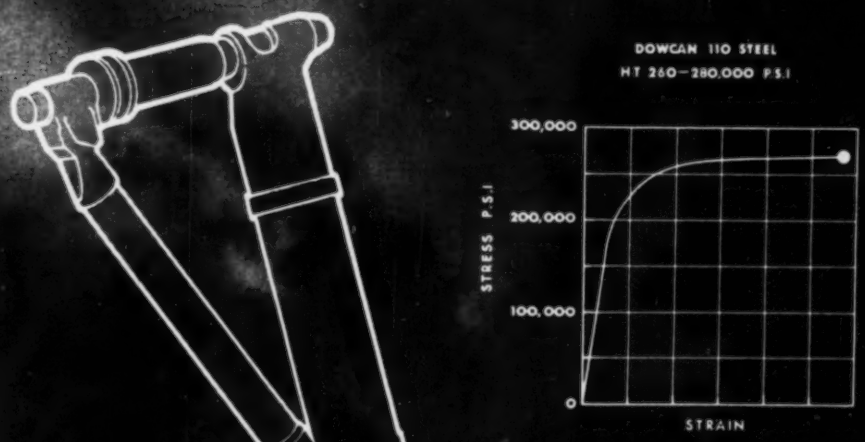

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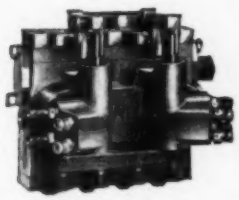

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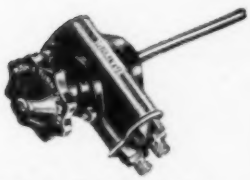

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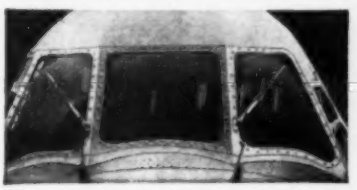

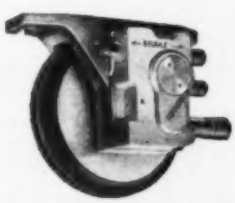

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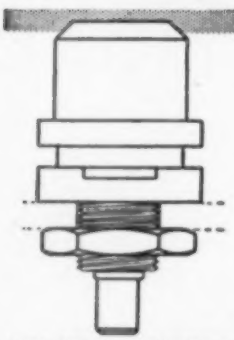

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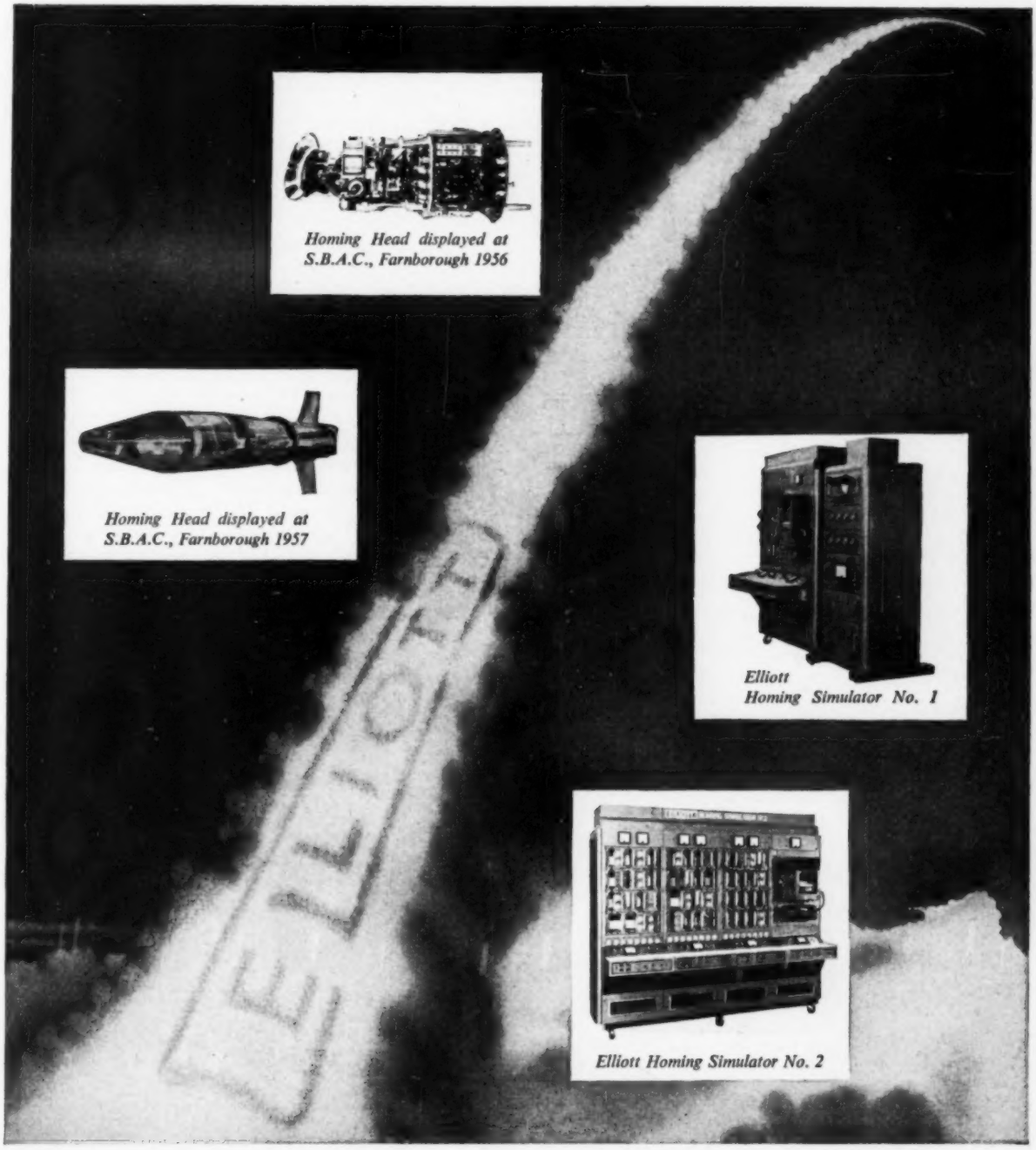

Homing Head displayed at S.B.A.C., Farnborough 1956

Homing Head displayed at S.B.A.C., Farnborough 1957

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and
AIRCRAFT ENGINEER

No 2544 Vol 72 FRIDAY 25 OCTOBER 1957

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Associate Editor
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Technical Editor
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The New Rationalism

THE near-hysteria that followed the Defence White Paper of last April has now been largely soothed—not by political bromides but by the prevalence of good sense within the aircraft industry itself, the Ministry of Supply and the user Services. The wolf that suddenly appeared at the door turned out to be just a sharp-eyed (and sharp-fanged) watch-dog. He has lain down on the mat and he watches benignly while the industry goes about the job of tidying up and rearranging its resources to receive new business.

The pattern of the rearrangement becomes clearer as new Service requirements are formulated, and as the means of meeting those requirements are prescribed. The purblind brotherhood of the "no-more-manned-aeroplanes" shibboleth stands openly discredited.

It is now obvious that the R.A.F. and the Royal Navy are going to need inhabited aerodynes not merely of new types, but of entirely new classes; and even among existing classes the seal of doom has been officially affixed to only two, namely the *strategic* bomber and the fighter. A reprieve for the bomber—the prodigious Avro 730—is the forlornest of hopes; and such regrets as linger are more for its potential as a research tool than as a strategic weapon. But for the fighter the bell may not have tolled with such finality. People have been so persistently assured that the P.1 is to be "the last manned fighter for the R.A.F." that their forgetfulness of the White Paper's precise terms is readily excusable. The actual wording was that "the R.A.F. are unlikely to have a requirement for fighter aircraft of types more advanced than the P.1"; and though that document affirmed that work on further projects would cease, it might equally have been ordained that, on pain of Ministerial proscription, the British aircraft industry would thenceforth abjure Virginia cigarettes and bitter beer.

Whether a new type will—or indeed should—succeed the P.1 in R.A.F. service remains conjectural. But should this never come to pass, we can still expect such extensive development of the P.1 itself that the term "new type" may well at length be justified.

The first of the "new classes" of aircraft to which we have alluded is represented by the Scottish Aviation Military Twin Pioneer—an STOL machine for "colonial" transport, trooping and policing. A second is the Saunders-Roe SR.177 mixed-power intercepter for the Royal Navy, and possibly for the West German Air Force also; and a third, it appears, will be a supersonic low-level general-purpose bomber of the sort we discussed on this page a fortnight ago. For the construction of such an aircraft (which, to reconcile short-field capability with supersonic performance, would demand technical resources of an extremely high order), a new system of "group tendering" may well be introduced by the M.o.S. It has been suggested that a condition attaching to the invitation to tender will be the co-operation of two or more firms, and such a development would certainly reflect the present rationalizing mood of the Government towards the aircraft industry. It would, moreover, conform with the industry's own tendency towards consolidation and redeployment—a tendency strongly evinced last week when it was made known that Sir Matthew Slattery, chairman and managing director of Short Brothers and Harland, had been elected a director of the Bristol Aeroplane Company and had been appointed chairman of Bristol Aircraft.

Pooled technical resources could make for improvement in quality, and combined facilities for production and development might speed delivery. A prerequisite for success, however, would be that the competitive incentive from which the strength and resilience of the industry has so largely stemmed shall not be impaired.

We had always harboured a suspicion that any lion that willingly lay down with a lamb must be either replete or in senile decay. Yet such happenings are now becoming commonplace, with Armstrong Whitworth, for instance, helping out with production of the Twin Pioneer. Last week we referred to "the new liberalism" in transport; and now, in respect of the aircraft industry, we think it appropriate to title these present reflections as above.

FROM ALL QUARTERS

Military Transports Demonstration

FOUR different types of British and American transport aircraft —two Beverleys and a Comet 2 of Transport Command, and a C-130 Hercules and C-119 Packet provided by the U.S.A.F.— were paraded at Boscombe Down last Tuesday for examination by the Air Transport Systems working party of the Anglo-Canadian-American Air Standardization Committee. In the morning all five aircraft were on static display, and in the afternoon one of the Beverleys, the C-119 and the C-130 demonstrated supply-dropping techniques over the Figheldean dropping zone.

The air transport systems working party is one of several branches of the Anglo-Canadian-American Air Standardization Co-ordinating Committee. It was not evaluating the aircraft themselves last Tuesday but examining different items of equipment in them with a view to standardization for joint operations.

A New Prescription

HOPES that the Proteus engine's icing problem may have been finally resolved were raised last week. Bristol have developed, and the R.A.E. successfully ground-tested, a device which directs compressor-tapped air to accelerate the boundary layer in the critical bend of the reverse-flow intake where the ice has been accumulating. The effect—yet to be proved in flight on Britannias —is to prevent ice deposits from building up. A modification to the shape of the air intake duct is in hand also.

Progress of the Satellite

AT the beginning of this week the Russian Earth satellite and its rocket case had completed more than 250 orbits of the Earth, amounting to more than 6.5 million miles. On Monday, October 21, the rocket case was 34 minutes and 10,000 miles ahead of *Sputnik* itself.

During the preceding week the news of the satellite's progress had fallen from first place in the world's Press, although its wider implications were the subject of much comment and discussion. On October 12, Dr. John Hagen, director of the U.S. Project Vanguard, estimated that the satellite would continue its flight for at least a year. Between October 12 and October 18 the period of the satellite's orbit shortened by about two seconds per day to 95 min 45 sec, and at the later date the mean orbit height was decreasing at the rate of two miles per day.

British support for the proposal (contained in the earlier 23-nation disarmament resolution) for an investigation into means of ensuring only peaceful uses for outer-space satellites and other objects was expressed before the United Nations General Assembly's political committee on Monday, October 14. On the following day, the satellite and rocket sub-committee of the British I.G.Y. committee decided to consider proposals to establish an Earth-satellite observatory in this country.

A Russian photograph of a dog inside a globe, said to have been carried to a height of 130 miles by a rocket, was released on Wednesday, October 16; this test was stated to have formed part of preliminary studies towards manned interplanetary flight. The mean heights of satellite and rocket were this day given as 130 and 100 miles respectively. A report from New York on October 17 said that Russia had inadvertently launched an Earth satellite in 1953, according to Mr. James Patterson, a member of the U.S. House of Representatives, and Soviet rocket specialists at the recent I.G.Y. meeting in Washington. This object was a high-altitude rocket said to have gone into orbit round the Earth for a few days after firing by the Soviet Army.

A Russian forecast that a "lunar physical station" would be established "some time, and maybe soon" on the Moon was made in Moscow on October 18, by which time the Earth satellite had completed 200 orbits.

Data obtained at Ministry of Supply establishments has continued to be sent to the I.G.Y. committee of the Royal Society. The main M.o.S. work has been carried out at the Royal Aircraft Establishment, Farnborough, where observations have included angular tracking by crossed radio interferometer techniques and radial velocity measurement by radio Doppler methods.

Next Year's World Gliding Contest

THE Soviet Union, U.S.A. and Britain are among the 19 countries which have already accepted the Polish Aero Club's invitation to take part in the 1958 World Gliding Championships at Leszno. The contest will be held from June 15 to 29, following one week of practice flying.

A maximum of four pilots may represent each country in the championships. The council of the British Gliding Association has decided to enter two pilots in each of the two classes, "open" and "restricted," and a pilots' meeting was to be held this week to determine the individual entries. The first four seeded pilots in this country are Cdr. Nicholas Goodhart, Lt-Col. Anthony Deane-Drummond, Philip Wills and Cdr. Anthony Goodhart.

The Etendard and NATO

IT is thought in Paris aviation circles that the Dassault Etendard will be the chosen NATO light strike-fighter. While in the Armée de l'Air, Marcel Dassault's new commercial director, M. Gallois, was attached to SHAPE and was in liaison with Dr. von Kármán and Col. Driscol in the evolution of the specification, so that the company is in an excellent position fully to appreciate the thinking behind it. The Sud-Aviation Baroudeur is understood to be well favoured by the American test pilots, probably in part because its cockpit dates from an era of more generous dimensions.

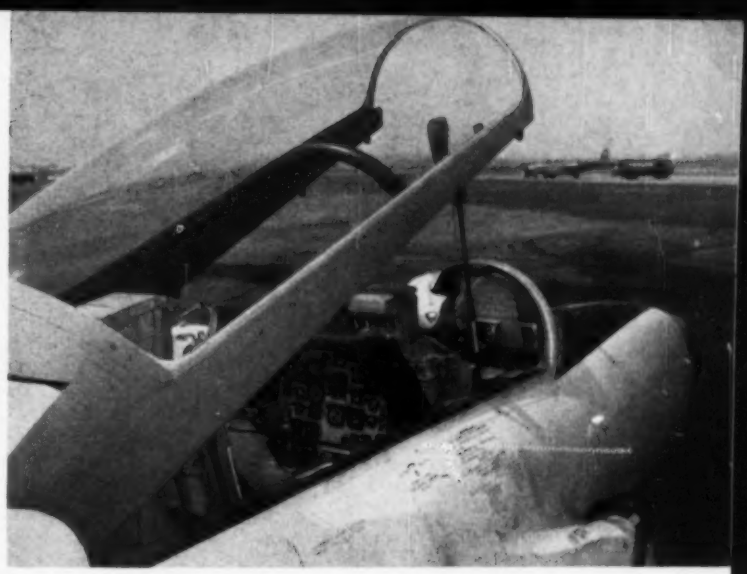
Navigation's Fix Eased

THE hopes expressed in our leading article of September 6 appear to have been to some extent realized in the findings of the sixth meeting of the I.C.A.O. Communications Division which ended in Montreal on October 14. The United States, in fact, proposed that the part of Annex 10 of the I.C.A.O. convention, including a D.M.E. specification of some five years ago which was hardly implemented, should be amended to accommodate the D.M.E. portion of Tacan. Such a system was now needed, they claimed, and was being provided at very high cost in U.S. territories.

The main opposition to this proposal came from the U.K. and Australia (the latter is already a general user of D.M.E.) because they did not consider that a rho/theta system allowed the full use of airspace and efficient air traffic control for faster airliners and increasing traffic. After several years' experience with a large number of D.M.E. beacons in their traffic control system, the Australians felt that D.M.E. was extremely useful, but not capable of meeting future requirements. Because of this, and of the findings of many committees such as the Jet Operations Requirements Panel and the Curtis Committee, neither Britain nor Australia felt that any change in the present Annex 10 material was advisable.

Both countries proposed, in detailed working papers, that a special meeting of I.C.A.O., made up of communications, operations and air traffic control authorities from all States, should be convened so that the problem of short-range aids should be

BOWMEN: On page 647 begins the most exhaustive analysis of the Avro Aircraft Arrow to be published anywhere. These photographs show some of the personalities involved in development. From the left: Harvey R. Smith, vice-president manufacturing; Harold Young, production engineering manager; R. N. Lindley, chief engineer; J. C. Floyd, vice-president engineering; Guest Hake, Arrow project designer; Jim Chamberlin, chief of technical design; and experimental test pilots "Spud" Potocki and Jan Zurakowski—both seen in the mock-up.



THROUGH A GLASS CLEARLY: Flight tests of the new flat-television-tube instrument panel, shown here in the front cockpit of a T2V-1, began last August. Douglas El Segundo have the co-ordinating contract for the U.S. Navy and Bell Helicopter Corp. have the same for the U.S. Army—mainly for helicopters. The system, first described in "Flight" for April 8, 1955, has now been released for use by civil operators, and Douglas hope to have it in operational service in two or three years' time.

thoroughly examined and an I.C.A.O. standard evolved. After protracted discussion in committees and plenary session it was decided that the Division should recommend to the Air Navigation Commission and, through it, the I.C.A.O. Council, that such a meeting be held at the earliest opportunity. It was agreed that no change to the Annex should be made in the meantime. The meeting will probably take place within 12 to 15 months.

A realistic step has thus been taken despite strong U.S. pressure; and it seems that civil aviation now has a chance to break free from the common system concept and to decide for itself what aid it requires.

An exchange of views also took place on long-range aids; and the French Radio Mailles (*Flight*, July 19), American Loran C (Cytac), Navarho Navaglobe, Omega, and British Dectra and Delrac were presented and discussed. Both American and British Doppler developments were set out, together with the Decca Integrated Air Navigation System, D.I.A.N. (*Flight*, August 23). Since this was an exchange of views, no standards were decided upon, but attention was drawn to the fact that the long-range aid, so far as I.C.A.O. was concerned, seemed as far off as ever, though the need for a long-range facility was daily becoming more urgent. Of the systems presented, Dectra would be evaluated in operation over the Atlantic by mid-1958, and Radio Mailles and Loran C would reach a similar stage in two or three years' time. It was accordingly recommended that development and evaluation should be completed as soon as possible and that an I.C.A.O. course of action should be established in order to find a standard at the earliest possible date.

Members of the crew of the M.o.S. Valiant making Dectra trials gave a talk on their work with the tracking and ranging patterns. Other recommendations covered secondary radar, radio teletype procedures, radio-telephony procedures, selective calling systems and single sideband systems.

Further Dectra Trials

IT is expected that aircraft of the major airlines will participate early next month in the next stage of trials of the Dectra system, with which Comets of R.A.F. Transport Command and R.C.A.F. aircraft are soon to be equipped. Recently (as described in *Flight* for October 11) a M.o.S. Valiant, on a flight from Boscombe Down to Montreal and back, navigated solely by the new system between 10 deg W and Gander.

Rarefied Descent

HAVING ejected from his F-100 Super Sabre when engine trouble developed over the Mediterranean last Monday, a U.S.A.F. pilot, 1st Lt. Herdis Clements, survived a fall from about 30,000ft without oxygen and was picked up from the sea (some four hours later) by the cruiser H.M.S. *Birmingham*.

Lt. Clements was flying from Tripoli to Etienne Airfield in company with two other Super Sabres. An R.A.F. Shackleton circled in the vicinity of his dinghy until the arrival of a U.S. Albatross rescue amphibian; this, however, unfortunately damaged an aileron and was unable to take off again, so Lt. Clements was transferred to *Birmingham's* whaler. Aboard the cruiser, which is flagship of the Mediterranean Fleet, Lt. Clements said he had been "quite happy" during the drop—though this feeling may have been due to the rarefied atmosphere.

Master of G.A.P.A.N.

A FOUNDER-MEMBER of G.A.P.A.N., Sir Frederick Tymms was installed as Master at a ceremony on October 16 at Innholders' Hall, London, following the second annual general meeting of the Guild as a livery company. Sir Frederick, who became one of the Wardens in 1955, has had a distinguished aviation career. In the 1920s he supervised the planning of the Cape-to-Cairo route and in 1931 he was appointed Director of Civil Aviation, India, becoming Director-General in 1945.

Viscount Test Mishap

THE Viscount 806-810, which Vickers-Armstrongs (Aircraft) have had on tropical trials in Africa, suffered damage while landing at Jan Smuts Airport, Johannesburg, on October 20. At the time of going to press the cause of the accident is not known, but it is reported that one main undercarriage collapsed, causing damage to the starboard wing and Nos. 3 and 4 engines. Fire (apparently quickly extinguished) broke out in one engine.

The Viscount concerned is G-AOYF, the first production 806, which has been temporarily engined with Dart 525s to accelerate the test programme of the production Viscount 810.

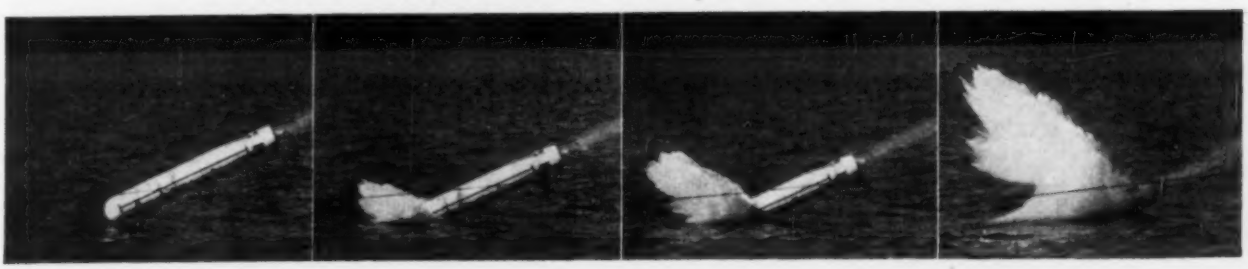
Shorts' Warning

A MEETING to discuss the employment situation in the Belfast factory of Short Brothers and Harland, Ltd., took place earlier this week, attended by company officials and by the executive committee of the Northern Ireland district of the Confederation of Shipbuilding and Engineering Unions. The meeting followed a notice issued by the company to workers on October 18. Signed by the management, this called for an all-out works effort; abandonment of all forms of petty restrictions by workers; and settlement of disputes through the proper trade union procedure.

The notice pointed out that the aircraft industry was now highly competitive and although the management were confident they could compete successfully in the civil aircraft sphere, difficulties were presented in Belfast by the continued pressure for increased earnings irrespective of effort. It went on:—

"This has had a serious effect on the state of the order on hand, and without having an opportunity of improving the standards of efficiency we are now faced with immediate redundancy and the prospect of having existing contracts withdrawn owing to our inability to meet reasonable prices and delivery dates. Action is necessary if we are to avoid immediate reductions in our order book and meet delivery dates."

FLYING "FISH": The exhibiting at the S.B.A.C. Show of two representations of a homing torpedo (for the Gannet and Whirlwind) lends a particular interest to this sequence of official photographs, which we print with acknowledgment to the "Journal of the Royal Naval Scientific Service." They show a full-scale torpedo, of unknown designation, entering the water at a speed of 300ft/sec. The sequence of frames was taken from a film made at about 180 pictures per second with a De Brie high-speed camera.



RESEARCH and its TOOLS

Wide Range of Activities at Short Brothers' New Facility

The newly opened three-storey building now occupied by the Research Department of Short Brothers and Harland, Ltd., at Belfast.

THE new three-storey building in Belfast which now houses the research department of Short Brothers and Harland, Ltd., was due to be officially opened by the Minister of Supply, Mr. Aubrey Jones, on Wednesday of this week. The method of opening was a novel one: it was arranged that the Minister should burn through a metallic tape, symbolically barring the entrance, with a 20 Mc/s high-frequency radio device made in the form of a "death-ray gun."

Originally inaugurated five years ago, the research department served only the precision engineering division, but it now works for all the company's divisions. At first it was housed in two laboratories of 1,200 sq ft floor area. Expanding in 1953, it absorbed a 5,000 sq ft wing of the new factory at Castlereagh, then spread to a further 4,000 sq ft of adjacent factory floor space. Work was balanced between contract and private-venture projects; and one of the most successful of the latter was the analogue computer, originally prepared for the aircraft design offices, but now widely supplied commercially. During the last three years Shorts have sold some fifty of these devices, about a dozen of them to the R.A.E. In addition, they use eight themselves, and have recently stepped up production from one to two per month. Development continues of further components, both hydraulic and electric, for these computers.

The department is not, in fact, interested in airframe, aerodynamic or propulsion work, and carries out what the Americans would term "systems engineering," though even this term does not properly describe the work. From specification to prototype, the department works on automatic control systems for aircraft, missiles and industrial applications; navigational systems and equipment; powered controls; computers and flight simulators; and all the components and techniques that go to make up such equipment. For this purpose, the department is now organized in four specialist sections, together with a systems group which co-ordinates the work, and a supporting laboratory services section. The whole is under the direction of the chief research engineer, Mr. E. Lloyd Thomas. The four sections are the analytical (Mr. M. E. Maxwell), the electro-mechanical (Mr. C. B. Flindt), the mechanical (Mr. I. K. S. Lasbrey), and the electronics (Mr. M. McFadden). The two chief systems engineers in the systems group are Mr. J. V. Roberts and Mr. C. Snowdon; and the laboratory services section is supervised by Mr. R. Gamble. Up to 200 technologists can be accommodated, but the present staff is about 90, of whom 85 per cent are techno'ogists and 75 per cent Ulstermen. Some 60 per cent hold degrees and 20 per cent have Higher National Certificate or an equivalent. The value of the test and measuring equipment available exceeds £1,500 per engineer; and it would be double this figure if permanent services and facilities were included.

The new research building itself occupies about 23,000 sq ft of floor space. Erected on the site of the "ideal farmhouse" built for the 1951 Festival Exhibition, it was completed in the short time of 16 months by the Northern Ireland Ministry of Commerce to the department's requirements. The architects were Ferguson and McIlveen, and the builders H. Laverty.

Arranged in a modular system, all rooms are enclosed by demountable partitions soundproofed where appropriate. Only the few permanent rooms have solid walls. A central corridor runs the length of the building beneath a locally lowered ceiling housing the main conduit for electrical supplies and other services. The ground floor accommodates the mechanical laboratory and test room with their heavy equipment; workshop; stores; generator room; and some special-purpose laboratories. The instrument and standards rooms on this floor are sealed and air-conditioned; and the former contains a special concrete pillar having its own special foundations 12ft down in the ground, for testing precision equipment in vibration-free conditions. A 3,000 sq ft electronics laboratory and the administrative offices, conference rooms and library occupy the first floor, while the top floor houses the electro-mechanical section, analytical section and systems laboratory. A lift serving all floors also gives access to the flat roof on which open-air tests of aerials and similar equipment can be carried out.

Nine colours are used for interior decoration, including dark tones for doors, woodwork and skirtings, medium tones for walls and light tones for ceilings and panels. The corridors have bright and astringent colours designed to isolate one room from another and to stimulate those using them.

The glareless fluorescent lighting is specially arranged so that 35 foot-candles intensity is maintained at desk height throughout, regardless of the position or re-positioning of partitions. From the generator room, electrical supplies at 400 c/s, 115 V, 3-phase; variable frequency; 100-200 V D.C.; 24 V, 100 amp D.C.; and 50 c/s, 230 V and 440 V 3-phase and various stabilized D.C. supplies are led to local control panels in each laboratory, where they can be selected by push-button and passed by ring main to numerous sockets at each group of work benches. Spare cables are also provided so that separate laboratories can be linked to one another for control or signalling purposes.

Other facilities include a fully equipped light mechanical and instrument prototype workshop; furnaces, ovens, balances, a hydraulic press, vacuum pumps and evaporation chambers; gyro test tables; high-altitude and humidity chambers; precision measuring equipment; hydraulic pressure rigs up to 6,000 lb/sq in, and 13 gal/min and load rigs; a coil-winding machine; and eight channel pen recorders, three Short analogue computers, special-purpose computers and servo-operated two- and single-axis rocking tables.

A goodly number of the research department ventures were on show during the opening ceremony, including the prototype of the fascinating visual helicopter-flight simulator, already described in *Flight* (September 27). Sound, cabin movement and yaw were not connected. Our representative, in this case a strictly fixed-wing operator, flitted erratically for many minutes over the land-

The mechanical test laboratory, showing hydraulic pressure rig, the controlled-rate hydraulic hoist, two-axis tilting platform and eight channel pen recorder.

Systems laboratory, left, and main electronics laboratory, right. The rig under test in the systems laboratory is the automatic control system for a drone aircraft, with servo load rig, aerodynamics computer, tilting gyro table and visual observation system.

scape projected on to the bowl-shaped screen and found the impression of horizontal and vertical movement so realistic that he had his attention drawn to paper bags thoughtfully located in the cockpit by the company (even relatively rudimentary noise and cabin tilting might well have rendered them absolutely necessary).

Other exhibits included an automatic height-control for helicopters, which is an inertial system to the extent that it uses an accelerometer to measure vertical movements of the machine and feeds appropriate signals to the collective-pitch control. This can itself be over-ridden manually when the pilot wants to alter height. A hydraulic controlled-rate hoist is being prepared to test this and similar systems. The accelerometer is the so-called medium-accuracy unit which has a coil floated in a radial magnetic field. With a 400 c/s, 115 V supply, it produces D.C. voltages proportional to acceleration. Its sensing range is -0.5 to $+1.5$ g.

Very small pick-offs with D.C. output proportional to angle or rotation and fitted with potted transistor rectifiers were also shown. Versions for rotary or linear movement were included. The department is also working on a miniature torque-motor which will produce mechanical movement in response to currents of a few milliamps. Called the Flindt-motor, it is light, robust and cheap; and it has apparent advantages over existing components of this kind.

Much work is being devoted to electrically signalled hydraulic-control devices. A pressure-control valve of this type has a high frequency-response and maintains constant pressure during large variations in flow demand. It can also serve to restrict flow and might be applied in powered-control systems where the power of a control surface actuator had to be limited or varied according to electrical signals proportional to height or speed.

An electro-hydraulic transducer, also displayed, uses a diaphragm displaced by electro magnets to vary the flow, and thus the pressure, in two oil jets venting on to the diaphragm. Changes in back-pressure then operate a spool valve which controls oil flow to an actuator. Present models develop 1 h.p., while up to 15 h.p. is foreseen for future versions.

There was also a remarkable 30 h.p. hydraulic motor with two opposed multi-piston, rotating-swashplate units, the pistons acting in pairs without valves. The power/weight ratio, in h.p./lb, is 3 : 1.

An electronic time-delay unit was shown which can produce delays from 0.5 milliseconds to 0.5 sec and can be used to simulate pilot-reaction time in test rigs. The already publicized low-frequency oscillator, for servo-system testing, was also demonstrated. Made up from Short computor components, it can produce frequencies down to 0.01 c/s.

Metallic-film potentiometers using fine deposits of resistance materials or noble metals on suitable surfaces are also being developed under contract to the U.S. Army.

Another venture, of a contrasting kind, is foamed resin, poured cold, cured and covered with glass-cloth, which is used for stabilizing fillings or panels. It is light, uniform, cheap and simple, but fulfils the same general function as the various honeycombs.

Work is in hand on components suitable for inertial navigation systems, and one of these is a high precision accelerometer. Using feed-back, it has a range, at present, of ± 5g, and a linearity of better than one part in ten thousand. In the systems laboratory a complete automatic control rig for a drone aircraft is laid out. Complete dynamic simulation of a high-speed aircraft under autopilot control is achieved, with a two-axis rocking table (representing airframe movement), three-axis control surface and servo load rig, aerodynamics computer and a visual display system showing the translation of the aircraft in space.

Work of this kind, applied to both missiles and aircraft, is now continuing apace at the Castlereagh building. Not only is the department well qualified to do its important work, but it is also as well housed and equipped as any in the British Isles.

MISSILE COSTS

AN unofficial report from Los Angeles gives the prices of the cheapest and most expensive missiles at present in production in the U.S.A. The first is the Philco/G.E. Sidewinder, an infra-red homing air-to-air weapon which is stated to cost $4,400 (£1,520); the latter is the Convair Atlas, the first of the two ICBMs which is stated to represent an outlay of $4m (£1,429,000).

DUTCH TARGET TRIALS

FROM The Hague it is reported that the AT-21 radio-controlled target, by the Dutch Aviolanda company, has made a first successful test flight over the North Sea. Described in our issue of November 4, 1955, the AT-21 is an 18ft-long vehicle, powered to a high subsonic speed by a SNECMA (French) resonant-duct engine.

COMMON SYSTEM RADAR BEACON

NECESSARY technical characteristics for joint civil/military air traffic control radar beacons in the U.S.A. have been agreed by the air traffic control and navigation panel of the Air Co-ordinating Committee, and the American authorities may now attempt to obtain international recognition for this system. The beacons allow tracking and identification of aircraft under radar surveillance by responding to the pulse from the search radar with a return signal. Similar progress is apparently being made with Vortac for use on American airways.

P.S.C. POST

FROM Toronto comes news that Col. C. A. K. Innes-Wilson, C.B.E., has been appointed South American representative for the Photographic Survey Corporation. He was due to take up residence at Caracas in mid-September. Col. Innes-Wilson had his first contact with P.S.C. when as surveyor-general of Pakistan from 1949 to 1954 he was in liaison with the corporation about its integrated resources survey of that country under the Colombo Plan. His first experience of air survey occurred in 1930, when he became a member of a Survey of India party carrying out work on the north-west frontier. He was twice mentioned in dispatches for his military services; and was awarded the M.B.E. (Military) in 1943, O.B.E. (Military) in 1945 and C.B.E. (Civil) in 1954. When he retired in 1949 from the Survey of India (of which he became director, being also Director of the Eastern Circle and Deputy Surveyor General of India). Col. Innes-Wilson was survey adviser to the Air Survey Co. of India for six months, before taking up his Pakistan appointment.

Col. Innes-Wilson.

"FLIGHT" NEXT WEEK:—

An enlarged special number—
Commercial Aircraft: Airliners of the World

HERE AND THERE

Nuclear Dunking

A WHIRLWIND helicopter from R.A.F. Valley has been used in making radiation tests at the Windscale plutonium plant. With F/L.s H. W. Gumbrell and P. B. Smith as crew it made flights about 100ft above the chimney of the damaged No. 1 nuclear reactor. During these surveys, physicists aboard measured radioactivity.

G.A.F. at Croydon

THE first German military aircraft to land at Croydon Airport since before the war, two West German Air Force Dakotas, flew in there from Fuerstenfeldburck, near Munich, last Saturday. With German crews and American instructors, they came to pick up spare parts.

Good Try

AN American pilot, William Wyatt, set out from Galveston, Texas, on October 18 in a Mooney Mk 20 to fly non-stop to Rome (5,695 miles). Airframe and engine icing forced him to ditch at night 40 miles off the northern coast of Spain, where he was picked up unhurt by a fishing boat and taken to Corunna. He was attempting to beat Bill Odom's Bonanza record of 4,973 miles from Hawaii to Washington.

A. Cdre. Whittle Honoured

At the Institution of Mechanical Engineers last Friday, A. Cdre. Sir Frank Whittle (who is an honorary member) received the John Scott Award. This is given to "men of science and engineering whose work has benefited mankind," and previous recipients have included Orville Wright and Igor Sikorsky. Founded just over 140 years ago, the award is now administered by the Franklin Institute of Pennsylvania and amounts annually to $1,000 (just over £350).

TURBOJET PIONEER Sir Frank Whittle receives the 1957 John Scott Award (plus a scroll and $1,000) from Mr. Emil A. Kekich, the U.S. Commercial Attaché in London. As recorded above, the presentation took place at the Institution of Mechanical Engineers.

A LIFE ON THE HERTZIAN WAVE: Towed away in his admiral's space-barge (local conversion of a Seafire 17), Rear Admiral C. L. G. Evans is given a ceremonial send-off after hauling down his flag at R.N.A.S. Yeovilton. Formerly Flag Officer Flying Training, Admiral Evans has been appointed Deputy Chief of Naval Personnel (Officers) and Head of the Directorate of Officer Appointments, as announced by the Admiralty on October 15.

Howard Prize Award

FOR his treatise on *Turbine Discs for Jet Propulsion Units* (an account of work by the disc panel of the M.o.S. Gas Turbine Collaboration Committee during the years 1941-49) Mr. A. E. Johnson, D.Sc., M.Sc. (Tech.), M.I.Mech.E., has been awarded the Howard Prize of £50 (for a treatise on some aspect of the subject of motive agents) by the Royal Society of Arts.

"FLIGHT" NEXT WEEK

OUR next issue, dated November 1, will be the annual "Commercial Aircraft—Airliners of the World" special number. Greatly enlarged, it will contain numerous cut-away drawings and descriptions, with performance data, of the new machines—British and foreign—that are likely to dominate the air-transport scene during the years ahead.

Peripatetic E.P.9

AN E.P.9 piloted by Mr. Harold Best-Devereux, chief of the sales organization of Edgar Percival Aircraft, Ltd., left Stapleford Tawney Aerodrome last week for a sales tour of Finland. This was being undertaken in conjunction with a Finnish concern, De Jersey and Co.

Burma Survey Contract

A CONTRACT for an aerial survey of 200,000 sq miles of territory in Burma has been awarded to Fairey Air Surveys, Ltd., and its associate the Air Survey Co. of India. Valued at £200,000, this is believed to be the largest single contract for aerial photography ever signed between a government and a private firm. Operations are due to begin next month.

"Flight" Index

THE index to Vol. 71 (January-June, 1957) of *Flight* is now available, price 1s (by post 1s 3d), from Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Readers' own copies of this volume can be bound (with index) at a cost of 25s, postage included; or binding case and index are available separately, price 7s 6d (by post 9s). Copies for binding (with sender's name and address enclosed) should be forwarded to Iliffe and Sons, Ltd., Binding Dept., c/o 24 Pakenham Street, London W.1, and advice and remittance sent separately to the publishing department at Dorset House.

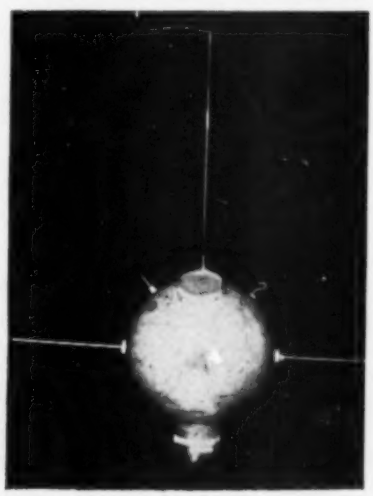
Mr. Geoffrey Lambert

AS we go to press we learn with regret of the death—on Saturday last, October 19, after a short illness—of Mr. Geoffrey Lambert, chairman of the Walter Kidde Co., Ltd. The funeral took place last Wednesday. Mr. Lambert inaugurated the British branch of the Kidde organization 32 years ago.

French Executive Jet

A PRIVATE-VENTURE twin-jet executive aircraft called the Méditerranée is being built by Marcel Dassault. A ten-seater, it is considered as an MD-315 replacement and has two Dassault R-30 turbojets. (The R-30 is the Armstrong Siddeley-designed MD-100 Viper derivative shown at this year's Paris Salon.)

HAVING SURVIVED RE-ENTRY to an allegedly denser atmosphere, this mysterious object was found at the door of a laboratory in a certain Mo.S. rocket research establishment. An investigation into the purpose of the sparking plug and shelf-hook is now proceeding.

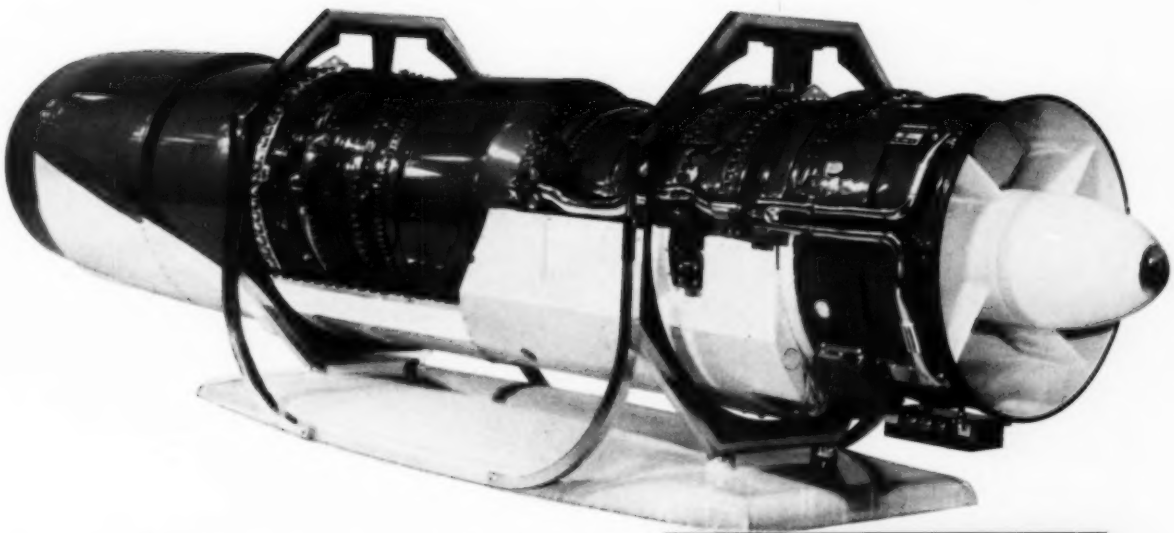


The world's newest supersonic jet engine...

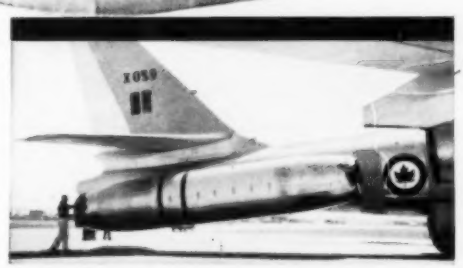
the

IROQUOIS

Selected to power production versions of the Avro Arrow for the R.C.A.F. the Iroquois is a jet engine of very advanced design, developing maximum thrust with minimum dimensions in a simple mechanical layout. Using modern materials including titanium, Orenda has developed an engine of very low weight.



The Iroquois designed, developed and produced by Canadians is the supersonic successor to the Orenda jet engine, 4,000 of which are in service on four continents.



FLIGHT TESTING THE NEW IROQUOIS AT MALTON
The supersonic Iroquois is carried in this specially designed pod at the rear of a B-47.

ORENDA ENGINES LIMITED

MALTON, CANADA

MEMBER: A.V. ROE CANADA LIMITED & THE HAWKER SIDDELEY GROUP

c

Indian Folklore 1957

We are proud of our association with Avro Aircraft Limited and Orenda Engines Limited in the development of the Arrow and the Iroquois. Specifically LUCAS-ROTAX has supplied

- the complete generating system,
- navigation light flasher,
- ground fault relay,
- and engine starter for the airframe,
- and the entire fuel system for the power units.

All this equipment, like the aircraft and engine, has been designed and manufactured in Canada.

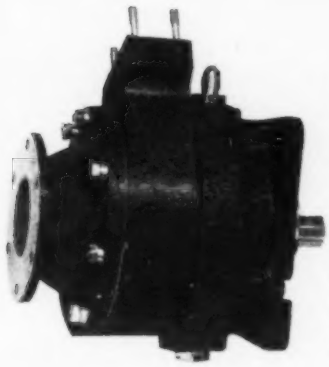
LUCAS-ROTAX

LUCAS ROTAX

TORONTO—2200 Eglinton Avenue East, PL. 5-4171 MONTREAL—5595 Royal Mount Avenue, RI. 8-7737 VANCOUVER—International Airport, CR. 8-5104

AIR-TURBINE DRIVES

Recent Developments by a British Manufacturer



The Rotax EXP.8009 air-turbine drive. This relatively small unit provides 3 h.p. at 4,000 r.p.m. at a typical high-altitude supply pressure.

UTIL ten years ago accessory power systems for aircraft followed a generally established pattern. Some aircraft designers tended to favour one system at the expense of others, but electrics, hydraulics and compressed air were all employed in a traditional manner. In nearly every case the system derived its power in the first instance from a direct shaft connection to the main aircraft powerplant. To a considerable extent this still holds good today but, particularly in the most advanced and complex types of aircraft, there is an increasing tendency to adopt completely new types of system.

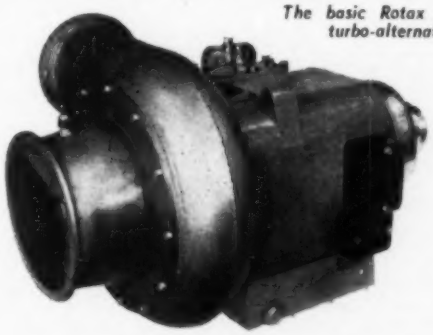
One overall factor behind this trend is that accessory power requirements are becoming progressively more arduous and difficult to meet. Another factor is that the increasing use of gas-turbine powerplants is making available ample supplies of compressed air—or, at least, can do so if the engine designer allows for it. As a starting point it is instructive to examine the accessory power system of a typical modern transport, and the Douglas DC-8 may be chosen as an example.

In this large, long-range machine primary propulsion is provided by four nacelle-mounted turbojets rated at more than 15,000 lb thrust each. Most of the heaviest accessory loads are met hydraulically, the system pressure being 3,000 lb/sq in. Each inboard engine has a mechanical drive to a multi-plunger, variable-stroke pump, and a stand-by system is driven electrically. All four engines are coupled to hydraulic drives on which are mounted 30 kVA alternators with three-phase, 400 c/s current at 115/208 V. Cabin air is supplied by turbo-compressor units driven by air bled from the high-pressure compressor spool of each engine. Hot air bled from the engines is also employed for airframe and powerplant de-icing.

Such a system is typical of a balanced layout not involving any extremes (by 1956 standards) of temperature. For aircraft designed to maintain sustained speeds in excess of about 1,000 m.p.h., kinetic heating may be sufficient to prohibit the use of any accessory systems employing oil, hydraulic fluid or conventional electric insulation—harsh restrictions indeed. Even where the complete airframe is still fairly cool, thermal limitations may make it impossible to bring any part of such systems into the proximity of the powerplant.

In such cases the designer is left with little to work with but stainless steel and hot air. Nevertheless, much can be done even

The basic Rotax 15 kVA turbo-alternator.



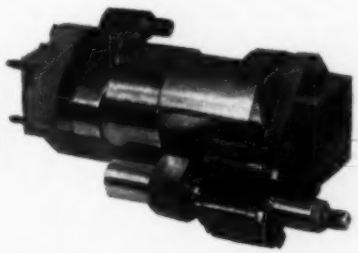
with these ingredients, and, particularly in the U.S.A., low-pressure air systems are already widely employed. In fact, such systems are even found in military subsonic (i.e., relatively low-speed) aircraft in which operating conditions are not particularly severe.

The thinking behind such a system is as follows. Air at up to 300 lb/sq in and 500 deg C can be extracted from the compressors of the main aircraft powerplants and ducted to any required part of the machine; the working medium (air) is cheap, light and continuously available; the ducting can have a thin wall and be of moderate weight per foot run; no return line is needed; automatic control, synchronization and protection systems can readily be incorporated; at low engine r.p.m. (ground-idling for example) it may in certain circumstances be possible to extract more pneumatic power than could be taken out through a shaft; the air supply, and hence the power and the r.p.m., of the accessory can be precisely controlled or automatically regulated; the latter can be done independently of the r.p.m. or power setting of the aircraft powerplants; an air-turbine drive contains few moving parts and can be made simple, reliable and light in weight; accessories do not have to be located close to the main powerplants but can be stationed in any convenient part of the aircraft; and it is sometimes possible to match an air-turbine drive with a driven accessory and treat the unit as a self-contained package capable of installation wherever convenient.

It is also possible to make the fullest use of the inherent flexibility of ducted-air systems by incorporating air-cycle machines or secondary combustion chambers by means of which the temperature, and hence the total energy of the flow, can be raised or lowered. "Bleed-and-burn" systems can, if properly engineered, be made to deliver very high power for only a slight increase in weight over that of a simple low-pressure air system. Again, although the engine designer must make full provision for bleeding off the requisite flow of air from the aircraft powerplant, such a procedure is mechanically straightforward and simplifies the engine geometry; it eases the congestion produced by multiple drive pads and can obviate the need for a remote shaft drive entirely.

Naturally there are factors to be weighed on the debit side, but the foregoing arguments are so powerful that bleed-air turbines are now being accepted for all classes of aircraft. They have been particularly favoured in the U.S.A., and the classic application at the present time is undoubtedly the Boeing B-52, in which the whole aircraft accessory power is energized by compressor-

The EXP.8010 in-line control valve which governs flow according to the pressure in a storage vessel. It is intended to control turbines driving intermittent-duty accessories.



bleed air flowing to multiple turbo units. In Britain it is not permissible to enumerate military applications of low-pressure pneumatic systems, but it is possible to describe such air-turbine accessory units as have been placed on the open market.

One of the most important British firms in this field is Rotax, Ltd., of Willesden Junction, London, who have been engaged in the design and manufacture of air turbines and related equipment for airborne applications for several years past. Rotax air-turbine developments are entirely company managed and are not based on any previous American work.

Rotax are developing several sizes of air-turbine drive, each of which will eventually be offered as a rationalized source of shaft power suitable for a corresponding range of matched accessories such as alternators. Owing to the flexibility of a low-pressure pneumatic system, and the ease with which the r.p.m. of the air turbine can be accurately controlled irrespective of the power-setting of the aircraft powerplants, such a system becomes a feasible arrangement for driving multiple synchronized alternators. This presents a straightforward *modus operandi* for a fully paralleled A.C. system—which is now widely accepted as the optimum electrical system for large and advanced aircraft.

Development was initially concentrated upon a unit of modest size, matched with a 15 kVA alternator. A range of large units rated at 30, 60 and 120 kVA have been considered and development of the 15 kVA and 30 kVA turbo-alternator sets for airborne use is now at an advanced stage.

As a typical basic unit it is possible to describe the general engineering features of the 15 kVA machine. The basic alternator is a blast-cooled, two-pole machine incorporating an integral air-cooling fan and manufactured as a single unit complete with the turbine drive.

In a typical installation, the unit may be mounted within the

From left to right above are: the main on/off valve and emergency butterfly; solenoid controlled regulating valve; and pressure-reducing valve.

AIR-TURBINE DRIVES . . .

fuselage and fed with cooling air from a ram intake and with bleed air through a pipe leading in from a powerplant mounted on the wing. Alternator cooling arrangements can be provided to suit any application. From the supply pipe the bleed air is ducted to a turbine inlet casing, from which it expands through variable-area nozzles which control the flow into the blades of the turbine itself. Rotax carefully investigated the performance of inward-flow radial turbines, but found that, at the desired peripheral velocities, an axial-flow impulse turbine could be made both more compact and more efficient, and the latter pattern has in fact been chosen for all the Rotax units at present envisaged. In the 15 kVA machine the turbine wheel has an overall diameter of 7in and is machined from a single steel forging. The air leaves the turbine through a conical diffuser and exhausts to atmosphere through a 6in-diameter duct.

Both the turbine wheel and the alternator rotor are mounted close together on a common shaft, the governed speed of which is 24,000 r.p.m. In order to maintain the latter under all possible conditions of electrical loading and flight speed and altitude, an automatic system is arranged to regulate the flow reaching the turbine blades. Incorporated in the air-turbine unit is an electro-hydraulic servo system which is acted upon by a frequency-sensitive unit. The action of this unit is to provide the necessary signal, which is equal to frequency error, and use this to operate the variable-area nozzles. By this arrangement the frequency of the alternator is maintained constant. Separate controls using magnetic amplifiers are employed for protection and paralleling control of a complete generating system.

The servo, utilizing oil pressure from an integral hydraulic system, varies the area of the inlet nozzles in the turbine assembly. Over a year ago the variable-area nozzle design was subjected to an endurance test which included a quarter of a million operations carried out at 320 deg C to enable a useful life to be determined; nozzle wear during this test was not such as to render the unit unserviceable.

In addition to the above-mentioned speed control system a protection system is fitted which can, in emergency, shut down the unit completely. Should the turbine over-speed for any reason a centrifugally operated plunger rotating with the rotor shaft pierces a diaphragm which allows air to escape from one side of a differential-area piston assembly. The piston, through a connecting linkage, turns a butterfly valve in the inlet ducting to close off the flow. It is interesting to note that this overspeed protecion unit is not connected in any way to the main control system.

As already noted, the alternator is designed to operate at a controlled speed of 24,000 r.p.m., at which it generates three-phase power at 208 V and 400 c/s, under all conditions up to an altitude of 60,000ft and a maximum winding temperature of 150 deg C. Where system conditions permit a simple hydro-mechanical governor can be employed to provide wide-tolerance control but, with the precise system required for parallel operation, control of both voltage and frequency real and reactive power can be held to within very close limits. The frequency-sensitive circuit picks up changes from the nominal 400 c/s and the error signal is passed through a magnetic amplifier and fed to a polarized relay operating the hydraulic servo mechanism of the turbine nozzles.

The bleed line from the main powerplants has an outside diameter of 4in and, when D.T.D.171 stainless steel in 23 to 26 s.w.g. is used, the duct weight, including couplings, approximates to 16 oz per foot run, which is comparable with the transmission of power by electric cables or hydraulic piping.

In order to ensure that full electrical power will be available under all likely flight conditions, the bleed power has been based on minimum flight-idling Mach numbers of 0.25 at 20,000ft, 0.5 at 40,000ft and 0.735 at 60,000ft. At Mach numbers greater than these the turbine nozzles are automatically reduced in area to restrict the turbine power to that needed to match the electrical load. A non-return valve is incorporated in multi-engined aircraft in which a common supply manifold is fed by tapping from more than one engine.

With the engines running, a particular air turbo-alternator is selected by opening the master control switch. This has a two-fold action: one to cause the solenoid-operated butterfly valve to open and so feed air to the turbine; two, to unlatch the field contactor and allow the alternator to build up. At a predetermined output voltage the turbine speed-control system is brought into operation, and the magnetic amplifier/hydraulic servo sets the turbine nozzles to the correct area. Means are provided to prevent the machine over-running the nominal speed due to delayed "build-up" of the control system. The set is brought on-line by a relay in the protection unit—which, assuming operation to be faultless, closes when the alternator voltage and frequency are within the required limits.

To shut down, the alternator field is shorted out by moving the master control switch to the "off" position. This cuts off the supply to the frequency-control unit and in addition closes the inlet butterfly valve.

An obvious addition to the overall system is the incorporation of a coupling into the supply manifold for an external source of air at the proper pressure. Such an arrangment is virtually essential for the ground testing—and especially the hangar testing—of the aircraft electrical system.

The air turbine drive is yet another means of providing constant-speed shaft power for aircraft use, especially for the provision of constant-frequency A.C. electrical power. The hydro-mechanical drive is well known, but the pure hydraulic drive is another newcomer in this field. The hydraulic drive as a means of providing constant-speed shaft power is under development by the Rotax organization and will be used for driving alternators at constant speed. It could also drive any accessory.

BREAKING A CODE

FROM time to time our readers have expressed interest in such curious names as "Red Dean" and "Yellow Lemon," which have been publicly—if not officially—revealed as describing various British weapons or electronic systems. Without comment, we reproduce the following extract from our American contemporary *Aviation Week*:—

"British missile code names originally were based on two words, the first a color describing the type of guidance system and the second a word assigned to the project. Typical examples were Fairey Fireflash which was Blue Sky and de Havilland Firestreak which was Blue Jay. Bristol Bloodhound was Red Duster, English Electric Thunderbird was Red Shoes, Vickers infra-red air-to-air Type 888 missile was Red Dean. Other examples: Red Hawk and Blue Boar. Elaborate designation even included system for component coding but is believed to have broken down in practice and has been abandoned as designation system."

AND NOW OMEGA

BEING put forward by the American delegation at the sixth I.C.A.O. Communications Division session in Montreal is a new long-range navigation system called Omega. It transmits signals rather similar to those of Decca Delrac, but is developed from a much earlier U.S. Navy system known as Radux. In the latter system information was carried by a 200 c/s modulation of a 40 kc/s carrier signal. The airborne receiver switched from one to the other of two transmitters and compared the phases of the two received signals. The hyperbolic pattern set up gave a relatively coarse pattern of position indications and was not very accurate.

From this equipment Omega has been developed to transmit two patterns, a 10 kc/s basic hyperbolic system and lane identification afforded by the 200 c/s element. This offers ultimate accuracies rather finer than those of Delrac, but a rather greater possibility of ambiguity in position fixing.

Bristol Brigands still remain in R.A.F. service. Here is a T.Mk 4 (two Centaurus 57 engines), photographed at Blackbushe during Farnborough week.

AIRCRAFT INTELLIGENCE

Great Britain

English Electric P.1. Following a detailed study of the P.1 supersonic intercepter fighter in this country, *Aviation Week* reports: "With the power available the P.1 can hoist off under-wing fuel tanks, rockets, napalm or bombs. It could carry a bomb underneath the fuselage or a camera pack for photo-reconnaissance. The fuselage slipper tank, which has been flown on the airplane, could be either extra fuel, or a complete Napier Double Scorpion rocket pack to increase thrust by another 4,000 lb for altitude performance. Complete airborne radar, working with ground controllers for initial vectoring, is installed in the P.1B. Flight profile is the usual for an intercepter: short take-off, rapid acceleration and climb to altitude, one or two passes at the target and home again. Endurance is about half an hour, which is probably representative of a typical mission."

U.S.A.

Sikorsky S-61. This designation applies to a turbine-powered helicopter for the U.S. Navy. It will have the ability to float indefinitely, being equipped with a "flying-boat hull with sponsons." The leading edges of the sponsons are set at a high angle of attack to assist take-off. The two gas turbines are likely to be General Electric T58s; they will be mounted above the cabin, which will accommodate about 20 people. A commercial potential—particularly among off-shore oil operators—is foreseen.

Republic "Surveillance Drones." The U.S. Army is to have "combat surveillance drones" built by the Republic Aviation Corporation. One model is to be made immediately available under a $1.7 million contract, and a more advanced version will be supplied under a $3 million contract. In each case the drone will be zero-length launched and recoverable, and the first, which is under construction, is stated to be propeller-driven.

France

Fouga 170 Magister. The Magister two-seat jet trainer was placed in service a year ago at the Salon Flying School of the French Air Force. By September this year 16,272 flying hours, including 29,300 landings and 19,050 hours of jet-engine operation, had been logged. Of the 47 aircraft of the type used at Salon, six had exceeded 600 flying hours, two had logged between 500 and 600 hours, and five between 400 and 500 hours. A French announcement states: "It is of interest to note that no accident, however slight, occurred to the personnel since the Magister was first placed in service at Salon."

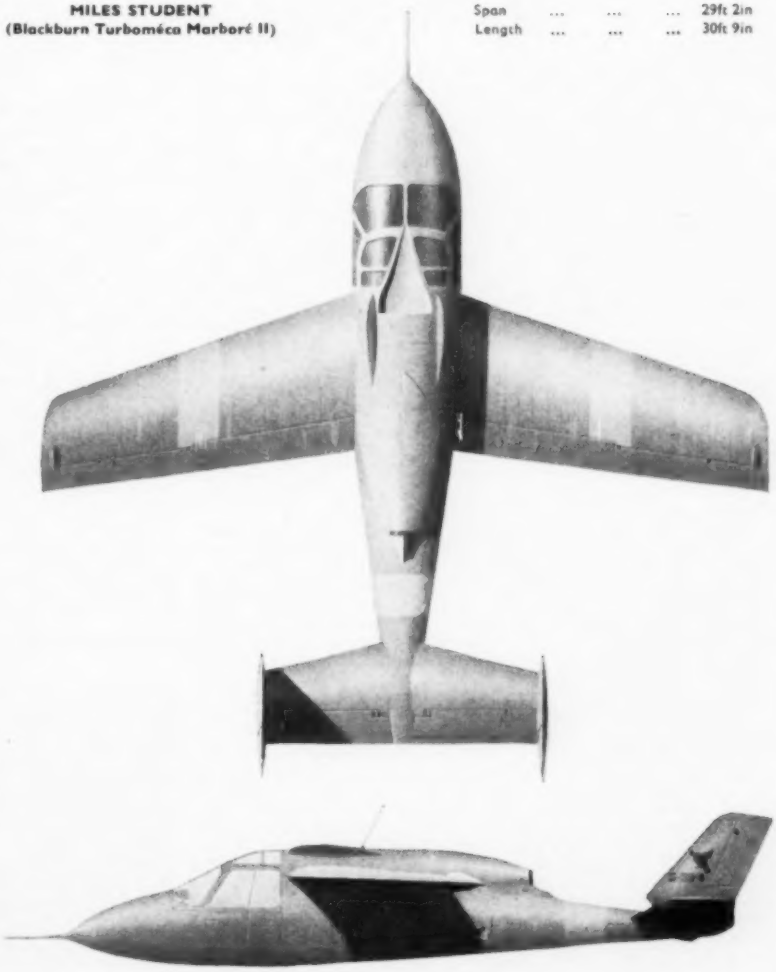
Max Holste Broussard. The Société des Avions Max Holste announces that it is now assembling a Broussard equipped with a wing having new high-lift devices. These consist of "a leading-edge slot and a new-type trailing-edge flap." Improvements are expected in take-off, landing and stalling speeds, and the new fitment can readily be incorporated in existing Broussards. The first aircraft so fitted should fly towards the end of this month.

U.S.S.R.

V.T.O. "Saucer." Writing in the popular journal *Knowledge is Strength*, published in Moscow last month, Prof. S. Zonshain is quoted as stating that saucer-shaped aircraft are in existence in Russia. He describes a machine with a disc-like wing provided with four circular apertures through which a power system sucks air and reduces the pressure above the wing while the resultant thrust is directed downwards. After describing current Russian airliners, the professor predicted that his country would soon be producing a supersonic transport.

MILES STUDENT
(Blackburn Turboméca Marboré II)

Span 29ft 2in
Length 30ft 9in



B.E. 2e 1916 — R.E. 8. 1917 — BRISTOL FIGHTER Mk 3. 1920/21 — WESTLAND WAPITI 1931 — VICKERS VINCENT 1937

No. 5 SQUADRON

A History of the "Fighting Fifth"

By JOHN YOXALL

PART 2

IN February 1916 there was some re-arrangement of units and in the St. Eloi actions in the following month No. 5 was working with the Fifth and the Canadian Corps. It was from their work with the Canadians that the squadron derived the maple leaf motif on its badge. At this time the unit was noted for its photographic skill. To quote official records, "Admirable photographs of the St. Eloi craters were taken by No. 5 Sqn., R.F.C., at 8.30 a.m., and were developed and printed with great promptitude. These photographs were joined up into a map which was in the brigade commander's hands the same afternoon." In those days plates—not film—were used and had to be processed separately.

The Battle of the Somme opened on July 1, 1916, but there was much preliminary work to be done by the R.F.C. along the whole line. On June 25 and 26 an offensive was launched against the enemy observation balloons. For this purpose Le Prieur rockets, fired from the interplane struts of Nieuport Scouts, and phosphorus bombs, dropped from B.E.2cs flown as single seaters were used. The squadron sent out four B.E.s so equipped—but with no success, owing to low cloud. For interdiction work, with a composite unit operating from No. 60 Squadron's airfield at Vert Galand, three B.E.2cs were allocated. Their work in the Cambrai area was very effective.

Preparations were made for quick movement forward if the expected breakthrough materialized, and the squadron's aircraft strength was brought up to 18. Just before the battle opened the C.O., Maj. Vaughan, left to take over command of No. 7 Sqn. and his place was taken by Maj. F. J. L. Cogan.

It was part of the strategy of the Somme struggle that the remainder of the line should be kept busy in order that the Germans should be denied quiet areas where battle-weary troops could be sent for a rest. Although No. 5 was not in the actual Somme area, the period to October, 1916, was spent in a variety of labours with interdiction bombing most prominent. Occasionally aircraft of the unit joined in what were for those days very large formations comprising 18 B.E.2cs for bombing with 11 fighters (F.E.2ds and D.H.2s) as escorts.

The outcome of the Battle of the Somme was not as was hoped for, and in the early part of October No. 5 was sent into the area, leaving Droglandt for the airfield at Marieux, which it took over from No. 15 Sqn. Here there was less bombing to be done but a lot more artillery observation. The squadron received congratulations on its ranging from Gen. Longcroft, who commanded the Fifth Brigade, R.F.C., to which the unit now belonged. But all flying over the enemy lines, especially by such outdated aircraft as the B.E.2cs were by then, was at a price and air fights, with resultant casualties, were frequent. No. 5 pilots, however, often gave a good account of themselves in these battles.

When 1917 opened the squadron had another change of command, Maj. G. L. P. Henderson taking over. One of the flight commanders at the time was Capt. T. Leigh-Mallory, who in the 1939-45 war became Allied Air C-in-C. under Gen. Eisenhower. Within a month, command had passed to Maj. Lewis, his predecessor having returned to England, and the squadron moved in March, first to La Gorgue and then to Savy, near Arras. The B.E.2cs had given way to B.E.2es—an improvement, but only a slight one.

A glimpse of war as it was then is given in the squadron diary for this time. "Lts. Buckton, pilot, and Barritt, observer, were on 'line reconnaissance' over Oppy when two enemy single-seaters attacked. Barritt returned the fire but his gun jammed. Buckton contrived so to dodge as to allow his observer to overcome the jam and bring his gun into action again. Unfortunately it stopped again immediately and the B.E. was raked at point-blank range. The petrol tank, engine, wireless set, airscrew and planes were repeatedly hit and the elevator control-cables shot away. There remained little else to do but land. This Buckton did, with the result that the B.E. struck the ground without flattening out and was completely wrecked; but neither occupant, miraculously, received injury. . . . Salving their two Lewis guns, Buckton and Barritt left the wrecked aircraft and started off to seek the shelter of a sunken road. They had not progressed far when they encountered a patrol of eight German infantrymen, whom they engaged with machine-gun fire, dispersing them in all directions. Shortly after, another patrol was observed, but this one approached from the west and was composed of Canadians. On their way back to the British lines they found the remains of an R.E.8 and succeeded in obtaining identifications from the bodies of the two officers lying under it."

Commanding Officers of No. 5 Squadron

	from		from
Maj. J. F. A. Higgins ...	26/7/13	S/L. W. T. H. Nichols ...	12/11/38
Maj. A. C. H. MacLean ...	18/11/14	S/L. N. F. Simpson	5/1/40
Maj. A. G. Board	19/4/15	S/L. E. T. T. Nelson	16/8/40
Maj. J. G. Hearson	22/12/15	S/L. A. J. Young	14/11/40
Maj. R. M. Vaughan ...	6/5/16	S/L. J. R. Maling	21/2/41
Maj. F. J. L. Cogan	16/7/16	S/L. J. H. Giles	2/3/42
Maj. G. L. P. Henderson ...	26/1/17	S/L. W. Pitt-Brown	23/5/42
Maj. R. E. Lewis	14/2/17	S/L. P. Bond	17/10/42
Maj. E. J. Tyson	16/5/17	S/L. G. J. C. Hogan	13/3/43
Maj. C. H. Gardner ...	11/3/18	S/L. J. M. Cranstone ...	15/6/44
Maj. G. Knight	4/11/18	S/L. L. H. Dawes	20/1/45
Maj. D. F. Stevenson ...	2/3/19	S/L. F. Rothwell	6/6/46
Disbanded	20/1/20	Disbanded	1/8/47
S/L. P. C. Maltby	1/2/20	S/L. D. H. L. Farmer ...	11/2/49
S/L. A. J. Capel	12/1/24	S/L. A. F. Wilson	–/10/50
S/L. O. C. Bryson	9/11/28	F/L. M. W. Huggins	1/1/51
S/L. W. K. Mercer	13/10/31	Disbanded	24/9/51
S/L. A. B. Ellwood	12/12/32	S/L. V. G. Daw	8/4/52
S/L. C. N. Ellen	21/11/33	S/L. C. S. West	7/4/53
S/L. P. F. Fullard	15/7/35	S/L. P. V. Ayerst	19/1/54
S/L. H. R. McL. Reid ...	25/2/36	S/L. T. P. Fargher	23/2/56
S/L. L. W. Cannon	18/4/37	Disbanded	12/10/57
S/L. H. J. G. E. Proud ...	9/12/37		

If No. 5 had missed the worst of the Somme fighting in 1916, it had its full share of the fighting at Arras in April 1917. The Germans here were very strongly entrenched, and only the most devoted work was rewarded by successful artillery shoots.

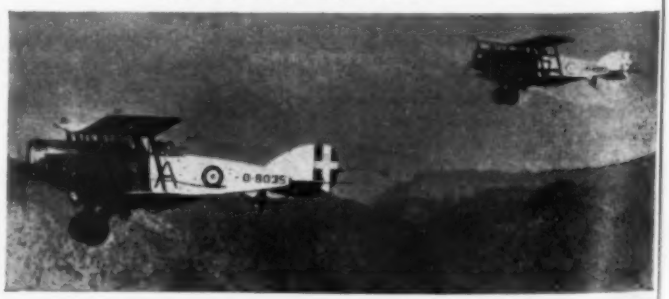
By June the main centre of the fighting on the British front had moved north to Messines, away from No. 5's front; but there remained plenty of fighting to occupy the squadron pilots and observers. For the summer, "B" Flight was detached to work with Fourth Brigade, R.F.C., operating from Moeres in the north. The flight rejoined its parent unit in December.

At this time the squadron was again re-equipped. The last of the B.E.s had gone and R.E.8s had taken their place, a considerable improvement. The latter were the first aircraft to have a tail trim.

In a variety of accounts of work done by individual crews there appears this note in the diary. "Capt. J. C. Slessor, with Lt. J. Tymms, observer, distinguished himself by a fine contempt of the enemy's trench machine guns, carrying out wire reconnaissance from under 200ft in conjunction with most thorough artillery observation." Capt. Slessor, it will be remembered, has become a Marshal of the R.A.F. and was Chief of the Air Staff.

Having excelled at artillery observation, day bombing and other tasks, No. 5 is next heard of in the night bombing rôle—on the Third Army front prior to the Cambrai operations which opened

Bristol Fighters of "A" Flight over the Malakand Pass, on the North-West Frontier of India, in 1927.



VICTORS

DECISIVE MILITARY BLOWS

Of WELLINGTON it was said "The sight of his long nose among us was worth 10,000 men any day of the week". Victor of the Peninsular Wars and Waterloo, he frustrated Napoleon's ambitions and finally crushed his empire.

Today decisive military blows—more crushing by far than those of Wellington—can be struck by the . . .

VICTOR—BRITAIN'S PREMIER STRATEGIC BOMBER

HANDLEY PAGE RADLETT LONDON READING

UNIVERSAL ROTARY ACTUATORS

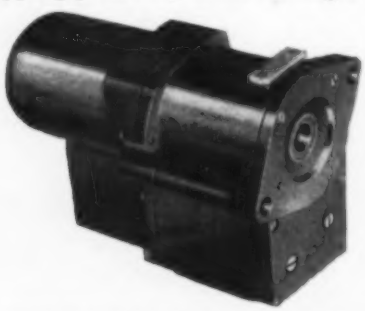
We are now in production with a Universal Rotary Actuator which greatly simplifies the work of the aircraft designer, constructor and operator.

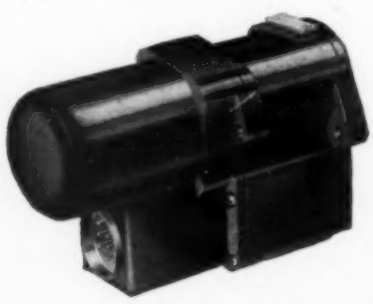
With this design, one basic Actuator can do a wide variety of jobs—and can easily be adjusted by the customer to suit specific applications.

One and the same Actuator can be adjusted either for total rotation in either direction, or for a total angle of rotation of 180°, with a mid-stopping position, or for an angle of rotation of any lesser total than 180° (in steps of 5°) while still retaining the mid-stopping position.

The ENGLISH ELECTRIC Universal Rotary Actuator operates on D.C. of 18 to 29 volts, has a normal loading of 50 lb. ins., and embodies a high overload capacity over a temperature range of —55°C to +150°C.

Very early delivery of these actuators can be made to meet orders. Full details and dimensions, and advice on their use, will be sent to you on request.





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AE56

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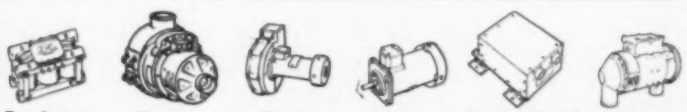
aircraft equipment



No.5 SQUADRON . . .

on November 20. The raids were often carried out in conjunction with No. 10 Sqn. In addition the squadron was busy with artillery observation on its own front, and an interesting point concerning conditions at the time was that whereas in 1915 —when A.A. guns were thinly sited and inaccurate—shoots were conducted from 6,000ft, in the latter part of the war, in the interests of accuracy, they had to be done from sometimes as low as 1,000ft. And by then A.A. guns were thick on the ground. The work was both arduous and dangerous.

The year 1918 opened with very bad weather; nevertheless the day-to-day work of the squadron went on whenever conditions were at all possible for flying. In March came the last real thrust by the Germans, by which they recovered all the ground lost in the Somme battle. These were hard and anxious days for the R.F.C., indeed for the whole British forces; but the German effort eventually weakened and the initiative passed to the Allies. It was during this battle that—on April 1, 1918—the Royal Flying Corps and Royal Naval Air Service amalgamated to form the Royal Air Force.

At this time, No. 5 was at Acq; but on May 25 a move was made to Le Hameau and it was at this airfield one night in early August that the Germans bombed the squadron, their attacks lasting three hours. Seven airmen were killed and more than a dozen wounded. The sergeants' mess was demolished and a canvas Bessonneau hangar with three R.E.s, inside was destroyed by fire.

The squadron, still working over the Canadian Corps, was soon to witness the beginning of the end of stalemate trench warfare. The squadron diary is again quoted: "The Battle of Amiens opened at 4.20 a.m. on August 8, 1918, with an artillery bombardment of unparalleled intensity, which completely disorganized the enemy's artillery and took him, as completely, by surprise. A thick mist covered the ground.

"Into this mist at 4 a.m. four R.E.8s of No. 5 Squadron climbed, regardless of the adverse conditions, and overcoming the restricted visibility by flying level with the tree-tops. One, piloted by Lt. F. C. Russell, was shot down in the enemy support lines. The observer, Lt. L. J. F. Oertling, was killed and Russell taken prisoner. Another was forced to land to ascertain its whereabouts. The two remaining R.E.s stayed over the lines until relieved at 7 a.m.

"As the day advanced the sun penetrated and gradually dispersed the mist, disclosing a scene which few of those who witnessed it and survived would forget in their lifetime. The enemy was retiring in haste and confusion with British tanks and infantry following closely. On the British side the roads were packed with troops and transport moving east, while the open country was alive with prisoners moving back to the west."

That day an advance of between six and seven miles had been accomplished.

During the afternoon, the crew of another R.E.8—Lts. Fothergill and Parlee—lost their lives. Their aircraft was hit by a British shell while they were flying at 500ft. Risks attendant upon flying in the path of our own projectiles were additional hazards which had to be accepted.

A more unusual occurrence happened on August 9 when Capt. Goudie and his observer, 2nd Lt. Jamison, saw about 300 German infantry, massed in a sunken road, offering stubborn resistance to our advancing troops. Machine-gun fire from a low height changed their minds and soon pieces of white cloth were being waved as a token of surrender. The R.E.8 stood by until the whole party had been surrounded and marched off.

A measure of the squadron's work in this battle is revealed in these figures. Between August 8 and August 22, under the direction of its pilots over 250 hostile batteries were silenced or completely destroyed, 450 bombs dropped, 400 photographs taken and over 50,000 rounds of machine-gun ammunition fired at ground targets.

Next came the breaking-through of the Hindenburg line, where 13 German divisions were soundly beaten by 10 British, who captured 16,000 men and 200 guns. A new air duty in this battle was to fly so low as to make the Germans react and by doing so give away their position. Some of this done by No. 5 provided valuable information to the Canadian General Staff.

With open warfare No. 5 moved forward, and when the end of the fighting came on November 11 the squadron was at Aulnoy on the outskirts of Valenciennes. Later a move was made to Hangelar, on the Rhine, still with the Canadian Corps; and by March 1919 No. 5 was the senior squadron attached to the Army of Occupation, its R.E.8s now replaced by Bristol Fighters.

A "25th birthday" formation of Westland Wapitis—Risalpur, 1938.

On September 8, 1919, the squadron returned to England and was stationed at Bicester, as a part of No. 2 Group (Southern Area). Six-and-a-half years after formation, on January 20, 1920, No. 5 was disbanded—but only for a very short while. On February 1, it was re-formed from No. 48 Sqn. at Quetta, India.

For the period from 1920 to 1924 there are practically no records of the squadron's activities. It is known, however, that No. 5 took up permanent quarters at Quetta, operating under No. 3 (Indian) Wing. The squadron was commanded by S/L. P. C. Maltby, D.S.O., A.F.C. [now A.V-M. (ret.) Sir Paul C. Maltby], and was still flying Bristol Fighters. For its time, the Bristol Fighter was a winner, having a performance equal to many contemporary single-seat fighters. But in the Indian climate its performance suffered, the top speed varying from 100 to 110 m.p.h. Its ceiling was reduced to 17,000ft. Range was 2¼ hr except when an extra tank was fitted in the rear seat. Armament comprised a Vickers front gun and a Lewis gun on a Scarff mounting at the rear. Bomb-load was one 112 lb bomb or a 200 B.I.B. (baby incendiary bombs) container, plus eight 20 lb Cooper fragmentation bombs. In May 1924, when for the first time the titles of R.A.F. squadrons officially indicated their duties, the "Fighting Fifth" became No. 5 (Army Co-operation) Sqn.

By the time the new squadron designation had been approved, No. 5 had been moved to Dardoni in Waziristan, taking over from No. 31 Squadron, and was operating under No. 1 (Indian) Wing.

In addition to its normal work in co-operation with Army units the squadron's duties included fortnightly patrols to Wana and Tanai forts to ensure that they were occupied by khassadars and not falling into disrepair; demonstrations in formation over tribal areas where trouble was suspected; patrols to help the Army locate gangs of raiders; ferrying Army and political officers; extensive survey photography and, occasionally, actual operations against recalcitrant tribes.

The following rather light-hearted account of such operations is extracted from a diary written at the time. (In fact flying conditions in the mountains, especially in bad weather, were very grim):—

"The tribes of Mahsud and Wazir," the diary relates, "found the strain of good behaviour a bit too much at times. There were definite rules to this game, strictly observed on both sides.

"First the political agent would summon the tribal leaders to a *jirgah* at which he would tax them with their sins and pronounce the Government penalty—usually a fine of rifles or rupees. This was but the first of several meetings which the culprits utilized for the successive stages of denying responsibility, suggesting that half—or maybe a quarter—of the sum would be more in keeping with their resources, offering so much down and the rest in instalments and, finally, flatly refusing to pay.

"The P.A. would then issue his ultimatum which usually gave the tribe another week in which to get their caves habitable. The day before this expired the squadron would demonstrate over the village and drop leaflets tied to small pieces of rock and containing a reminder that all women and children should be removed. The fact that nobody could read was immaterial—everybody knew the rules.

"The 'war' might last anything up to a fortnight before the tribesmen would indicate their willingness to try and raise the necessary. It was generally accepted that the surrender was not brought about by the bombing—most of which made little impression on the strongly built

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"Flying conditions in the mountains, especially in bad weather, were very grim." No. 5 Sqn. Wapitis (above left) over typical N.W. Frontier territory. Right, at Agartala, Burma, in 1943 (where a contemporary comment records, "the pilots eat at tables of bamboo . . . sleep on bamboo beds . . . keep their belongings on bamboo shelves.") Left to right F/Sgt. Baines, W/O. McLaughlin, F/O. Snowball and F/L. Courtney-Clarke.

No. 5 SQUADRON . . .

forts and towers—but by the vermin with which the caves were infested.

"During one of these shows the [then] commanding officer, S/L. A. J. Capel, was shot down and imprisoned on the top floor of a tower as an inducement for the P.A. to call off the bombing. It continued, however, with the aid of information supplied by the prisoner, who managed to get messages through by means which were never divulged, but generally assumed to be the village idiot—a favourite rôle of those politicals who wandered about the countryside. Rumour had it that some of his observations on the squadron's bombing were crisp."

The foregoing incident was not as pleasant an outing as the above description would have the reader believe. For his remarkable courage S/L. Capel was awarded the D.S.O., and a few months later got the D.F.C.—two most unusual peacetime decorations and a great credit to No. 5.

Early in 1925 the squadron moved for a short while to Kohat, the first frontier station to be built specially for the R.A.F., and then on to Tank on the south border of Waziristan, where it took part in one of the major operations against tribesmen. The operations entailed some six weeks' intensive bombing by No. 5, reinforced by a flight from No. 20 Sqn. and a night-flying flight from No. 31, and Nos. 27 and 60 Squadrons. Locally known as "Pink's War" (after W/C. R. C. M. Pink, who was in charge of the operations), its participants were given an award—a "Waziristan 1925" clasp to the Indian General Service Medal.

A more normal type of Army co-operation squadron life was resumed in October 1925, when a move was made to join No. 2 (Indian) Wing at Risalpur and exercises were carried out with local army units. Flights, however, continued to be detached for special duties.

Through 1926, a year in which a total of 3,194 hours were flown, and into 1927 the Army co-operation work went on. The highlight of this period was the Delhi Display on February 21, 1927, when two machines from "B" Flight demonstrated message picking-up, three from "A" Flight made a three-point diving attack on a tank and two machines of "C" Flight competed in an inter-squadron relay race—the R.A.F. Hendon Display on a small scale. To augment the types of aircraft in the display two A. W. Siskins and two Fairey III Fs were sent out from England. After the show the two Siskins went to No. 5 Squadron for various tests under Indian conditions—today this would be termed tropicalization—and remained with the unit for more than a year.

Refuelling one of the squadron Wapitis from 2-gallon cans at Khanpur in 1938.

In June there was more trouble, this time in the Shabkadr region, requiring prompt action. No. 5 contributed four Bristols to a force of 20 aircraft, the other machines coming from Nos. 60, 27 and 20 Squadrons. The force met over Dand Banda in the evening with the Bristols below the D.H.9As, waiting for the *lashkar* [body of tribesmen] to put in an appearance—which it did within half an hour. Despite a bad dust storm an attack was made, dispersing the tribesmen and putting an end to the trouble in one go.

During 1927 the squadron flew 3,175 hours in its Bristol Fighters.

The New Year started with the usual round of practice Army co-operation and manœuvres. Some variety was supplied by the test which had to be made with an A.W. Atlas aircraft with supercharged A.S. Jaguar engine. (The Atlas became the standard Army co-operation aircraft for several years.)

Conditions were against the supercharged Jaguar. Overheating was its main trouble; but when a normally aspirated Jaguar out of one of the Siskins was fitted a successful aircraft resulted.

For the history covering those four years 1924 to 1928, S/L. Capel, who was C.O. at the time, is largely responsible.

Only the briefest information is available for the next few years, but it is certain that the unit remained in N.W. India, operating occasionally against troublesome tribes. In May 1931 the Bristol Fighters, which had been the standard equipment for over 11 years, were replaced by Westland Wapitis. The Wapiti was designed as a D.H.9A replacement, the original intention being to use 9A wings in store. In fact, steel wings were later made for them.

Apart from the welcome change of aircraft type, life with the squadron proceeded much as before with a continual round of shoots, air firing, photography, R/T practices and sports, at which the unit excelled. On July 28, 1934, No. 5 celebrated its coming of age. The day was observed as a holiday and in the evening all ranks were present at a dinner held in the open air.

In May 1935 occurred the great Quetta earthquake in which the R.A.F. quarters were directly involved. The worst damage appears to have been done in the very early hours of the morning and rescue work was hampered by the absence of light, for it was still dark and all the electric wires were down. What had once been the airmen's barracks was now nothing but a heap of rubble with a few survivors in a stunned condition wandering about calling to trapped inmates. Rescue work went on feverishly but fresh tremors often undid what had already been achieved. A battalion of Punjabis on a night march lent much help by digging with their entrenching tools and later some light tanks were available for pulling heavy debris away. Casualties were high. No. 5 lost one officer, 22 British and 17 Indian O.R.s.

The hangars, which were of steel construction, stood up very well to the earthquake although the brick flight offices mostly collapsed. The shaking, however, had been so violent that all the aircraft had been thrown about inside and dashed against each other and the walls. Inspection showed that only three out of the 27 belonging to the wing were fit to fly. The doors of the hangars were forcibly opened by tanks and by 10 a.m. the three machines were in the air, one of them taking the first news of the disaster to Sibi—the Quetta wireless station was out of action until midday.

Air reconnaissance revealed that the main damage extended 70 miles south from Quetta. The total death roll was estimated to be 56,000. In the days following the disaster every squadron in India ferried doctors, nurses and medical supplies to Quetta, carrying injured persons on return flights.

On July 8, 1935, a conference was held to discuss the future of the squadron and on the following day orders were received for the unit, on a two-flight basis, to move to Risalpur, N.W. Frontier Province. S/L. P. F. Fullard took over from S/L. C. N. Ellen. Total flying time for the month of July was only 38 hours.

By August 17 the squadron was back on operations against the tribesmen. This time it was the Burhan and Isa Khel who were causing trouble, attempting to destroy a road. Operations were carried out in three phases: (1) Between 0630 and 0900 hr attacks were made, each with one practice bomb, as a final warning. (2) From 0900 hr, and throughout the whole operation, there was a continuous patrol of one aircraft during daylight hours, augmented by night patrols. (3) Bombing attacks on selected targets, every care being taken to avoid loss of life or damage to property. An unfortunate accident occurred when some unused bombs were being removed from a returned aircraft. One bomb exploded, killing five and injuring 28. Of these No. 5 lost two killed and five injured.

Halfway through October 1935 the squadron occupied semi-permanent quarters at Chaklala with a 600yd × 500yd airfield close by. In typical British fashion, it is recorded that a number of flower beds were laid out.

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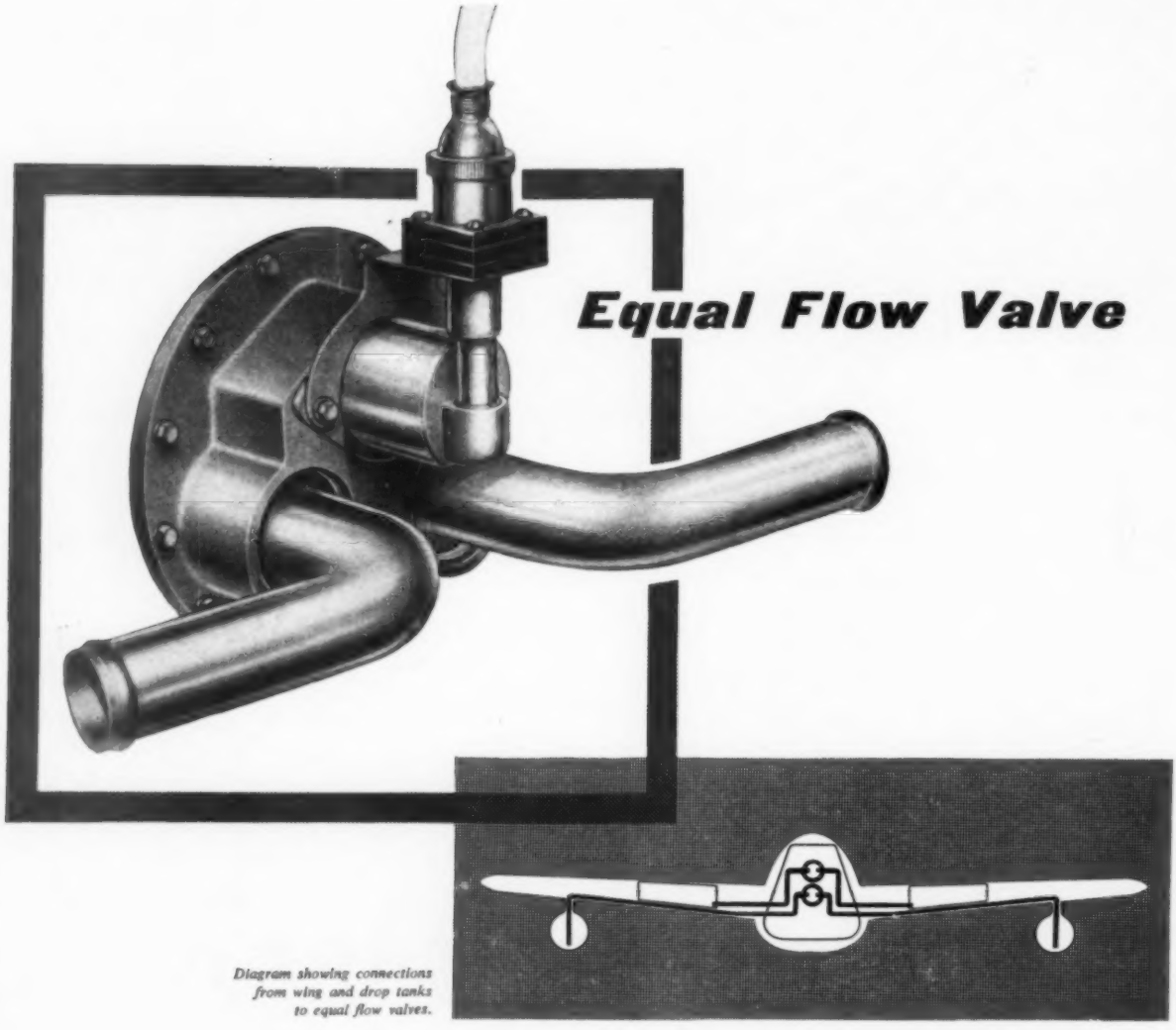

Diagram showing connections from wing and drop tanks to equal flow valves.

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Lord Louis Mountbatten, S.E.A.C. Supreme Commander (left) addressing the squadron during his visit in 1944; and (above) one of No. 5's Mohawks being serviced at Ramu during the Burma campaign.

No. 5 SQUADRON . . .

For the December manoeuvres a temporary airfield was prepared at Julalpur, but with considerable misgivings because it was thought that the landing ground would be impossible to use on account of either dust or mud. Actually no rain fell and a gentle breeze kept the field free from dust.

On the roll of officers for January 1936 appears F/L. G. W. Tuttle, who is now Deputy Chief of the Air Staff. During the early part of that year, flying was restricted owing to extremely bad weather, but, whenever possible, normal training flights were made. By March four more Westland Wapitis were flown up from Lahore and with the addition of these aircraft and some postings to the squadron it was feasible to return to a three-flights organization.

From April 1 the squadron took over Miranshah Fort in Waziristan, each flight remaining there for two months at a time. The fort was close to the old Dardoni camp where No. 5 first went after being re-formed in India.

No troubles were encountered until the following November, when "A" Flight at Miranshah were involved in minor operations. These consisted of rounding up sheep belonging to the Zilli Khel tribe as these were being grazed in a blockaded area. The sheep were finally returned to the tribe at a price of two rupees per head.

Later in the month and during December the Fakir of Ipi and his adherents of the Tori Khel country again made themselves a nuisance and kept the squadron fully occupied. So busy were they that Christmas Day was the only complete day on which no operational flying was done—and the tribesmen must have wondered why they were not harassed during that day.

At the beginning of January 1937 "A" and "B" Flights were at Miranshah, still on operational duties. "C" Flight was doing normal training at Chaklala. Nothing very exciting happened until February 7 when a car carrying pay for N. Waziristan was ambushed and looted. Immediately the whole squadron was put on various operational duties against the offenders. The affair developed into a serious action in which the Army was involved and suffered a number of casualties. No. 5 lost one pilot, F/O. K. N. Lees.

Late in April 1937 the unit moved to Risalpur, where a normal training programme was carried out while squadron personnel went in two parties to the R.A.F. Hill Depot, Lower Topa.

August saw the squadron back again at Miranshah, doing the usual reconnaissances; but the area was much quieter than when No. 5 was last there. During September, however, the Fakir of Ipi and his followers caused further trouble and operations were again carried out against them. The area did not settle down until November 1937.

All remained comparatively quiet—for that area—until the squadron again moved to Risalpur in April 1938; but its stay here was of short duration and in May No. 5 was at Arawali with No. 1 Wing, on operations once more, until going back to Risalpur and Miranshah in September.

The 1938-39 series of European crises, which cast their shadows of events to come, caused difficulties as far away as N.W. India. For instance, on one occasion "A" and "B" Flights were sent urgently to Miranshah to relieve detachments from Nos. 38, 11 and 28 Squadrons so that these units could prepare to move to their war stations. When hostilities broke out on September 3, 1939, half of the squadron was at Risalpur and the remainder at Fort Sandeman; in a month the unit was reduced to one flight.

For No. 5, war meant carrying on with the tasks (operational and otherwise) which they had done for so many years, but with only a third of the personnel and aircraft. In November they were visited by the A.O.C-in-C. Air Forces in India, Air Marshal Sir J. F. A. Higgins, K.C.B., K.B.E., D.S.C., A.F.C., who, as a major, had been their first commanding officer.

The familiar round continued until June 1940, when Fort Sandeman was handed over to the Indian Air Force and a move made to Lahore, where Wapitis were changed for Hawker Harts and the squadron's rôle from army co-operation to light bombing.

Details of the squadron's activities are again scarce until the entry of Japan into the war. In December 1941 a move was made to Dum Dum in defence of Calcutta. The Hawker Audaxes which were then on charge were converted to single-seaters before re-equipment with Mohawks, starting at the end of the month.

Although No. 5's duties included operations against enemy flying-boats in the Bay of Bengal, no actual contact is recorded. On May 5, 1942, the aircraft, pilots and 50 maintenance personnel proceeded to Dinjan, Upper Assam, where they absorbed the remainder of No. 146 Squadron. The remainder of No. 5 left at Dum Dum were absorbed into No. 146 Squadron.

At the new station, duties comprised leaflet dropping, standing patrols and escort to No. 113 Squadron's Blenheims. By July 6, 1942, contact with the Japanese was complete and each day from then onward sorties were flown attacking ground targets with bombs and machine guns. Bad weather at the time was a severe handicap. Targets were mostly on the banks of the Chindwin and Kyittha rivers. Only moderate A.A. was encountered.

A typical operation of the time occurred on August 11: "Two Mohawks carried out low-level and direct bombing attacks from Shwegyin to Kywe. Twenty 20 lb bombs were dropped and 1,000 rounds expended while diving from 5,000ft to 3,000ft. Six large barges and several boats and buildings on the river bank were damaged. A direct hit was scored on one large barge at Kyauktan. Approximately 200 burnt-out M.T. vehicles were observed in Shwegyin. No A.A. fire. Visibility good over the target. Weather generally stormy between Chindwin Valley and Imphal."

The first air combat came on August 20 when Sgt. Garnett, flying one of five Mohawks on an offensive reconnaissance, saw a Japanese Army 97. Closing to less than 100yd from dead astern he shot it down, the pilot baling out. The first report of enemy aircraft over the squadron base at Dinjan was in September 1942. No casualties are reported.

Another move came at the beginning of next month—to

No. 5 Sqn. officers and aircrew in 1944. Sitting (from left to right): F/L. Laurence, W/O. McLaughlin, F/L. Scanchett, S/L. Sharpe, S/L. Rashleigh, W/O. Worts, S/L. Hogan, ——, S/L. Courtney-Clarke, W/O. Ferguson, F/L. Thurston, P/O. Seifert, F/L.s Snowball and Thomas. Back row: F/O. Baines, F/Sgt. Parsons, F/O. Bailey, F/Sgt. Gore, F/L.s Trimble and Lee, F/O. Boyes, F/L. Bezts, ——, ——, F/O. Boyens.

No. 5 SQUADRON . . .

Agartala. The first operational flight from here was as escort to four Blenheims attacking shipping at Akyab. Ten Mohawks took part. Four Army 97s were seen over the target. It was thought that these bombers took off to avoid being destroyed on the ground, and one of them was shot down. In a similar operation on November 10 the Blenheims and Mohawks were attacked in force over the target. Despite one of the Mohawks being in collision with a Jap fighter, all returned safely, claiming two enemy aircraft destroyed, one probable and five damaged.

When 1943 opened the unit was still on operational duties at Agartala, escorting bombers and communications aircraft and making low-level attacks. In a mix-up over Akyab Island on January 19 there occurred another air collision. After damaging one enemy aircraft F/O. Boyes fired at the tail of an 01 which was attacking another Mohawk. Just as Boyes was about to break away the tail of the 01 swung up and cut about 4ft off the Mohawk's starboard wing, leaving a bit of the tail structure embedded there. The 01 crashed but Boyes got back safely.

These dog fights were severe while they lasted but they were the exception rather than the rule. Weather and the terrain could be much more dangerous enemies.

In March 1943 S/L. G. J. C. Hogan (now at the R.A.F. Staff College) took over command of the squadron. He has loaned the photographs published on pp. 644-5. The changing form of operations over Burma is seen in a report for March 18, 1943. Twelve Blenheims were bombing enemy positions north of Donbaik with five Mohawks in close support and Hurricanes providing top cover. (There was one difficulty. The Hurricane pilots thought the Mohawks looked similar to 01s but the higher authorities had a good opinion of the Mohawk's suitability for work over the Mayu peninsula.)

It was during March, too, that escorts were provided for supply-dropping DC-3s, and at the end of the month four of the squadron's pilots tried conclusions with six 01s at 12,000ft over "Reindeer," their own forward strip. Here the squadron diary is quoted. "S/L. Hogan gave the order 'Buster' and one after the other our men went down on them, the sun behind them. One 01 was flying below the rest. This S/L. Hogan singled out, getting in a full deflection shot abaft the cockpit. Pieces were seen to fly off. The C.O. then tried to follow him in a tight turn but the 01 flicked away. Now the C.O. was attacked from directly above and avoided the attack by diving and doing skidding turns. The C.O. reports seeing the 01 diving out of control and gushing black smoke.

"In the general dog-fight which followed the initial dive F/L. Rashleigh made a deflection attack on an 01, but as his windscreen was oiled up he could see no results. In the course of this attack another 01 got on his tail and Rashleigh's aircraft was immediately hit. . . . His rudder controls were shot away and one aileron was not working. Now smoke appeared in the cockpit. At this juncture the 01 broke away, probably because he saw F/O. Snowball coming at him.

"Rashleigh could not get his flaps down and made a belly landing at 140 m.p.h. near Karakipura. On account of the confined space at his disposal, actually a small clearing, he had literally to fly his aircraft into the ground.

"Three cows were killed in the process but Rashleigh stepped out of his aircraft uninjured and saw the engine lying many yards away. The first people he met pointed to the big village in an off-hand way and when he got there the villagers talked excitedly. Rashleigh heard the word 'British' and when he told them he was British the headman flung his arms around his neck and kissed him. The headman's son and a bearer brought Rashleigh back, a journey of 20 miles, on foot."

Out of the fight, claims were made for one probable and two damaged. It was but one fight of many at the time.

A comment on their living conditions said that "the pilots are living and sleeping in a basha which also serves as dispersal. It has a most tropical aspect; tall palms waving in the sea breeze and growing right against the bamboo walls. The pilots eat at tables of bamboo, they sleep on bamboo beds, they keep their belongings on bamboo shelves." (See the photograph on page 644.)

The next month, April 1943, was remarkable mostly for an attack made on the airfield at Agartala by 18 Japanese Army 97 bombers supported by 12 fighters. There were a number of casualties and considerable material damage was done, but No. 5 got away with one large hole in the fabric covering of an ambulance and damage to the M.T. hut.

It does not take long for any unit of the R.A.F. to make itself as comfortable as conditions allow, and so we find that at Agartala even the corporals had built themselves a club. Its interior decoration was silver and there was a bar, the sides of which were rich blue and the top apple green. Decorations included a picture of a magnificent liner steaming toward distant white cliffs (recognisable as Dover) and others of "very young and beautiful women."

May was again a busy month, for in addition to the usual escort work there were low-level attacks on Japanese positions and on the back areas, carried out at the Army's behest.

June 1943 was devoted to a move to Khargpur and a change of aircraft—the Mohawks being replaced by Hawker Hurricane IIs. Mr. Waterhouse of Rolls-Royce was there to instruct on engine problems. Not only was the move made for re-equipment but also as a rest for a hardworked squadron. Parties left for the hill station at Chakrata. July was spent almost entirely in familiarization flying on the new aircraft. S/L. Hogan went to Simla for an Air Co-operation (Hurricane A) Course. In fact the squadron remained in a training state until the first week in December, practising co-operation with the army, air interceptions and combats. For a while No. 5 became almost a training unit, outside officers—including some from the U.S.A.A.F.—coming to be instructed on Hurricanes. During this period night flying became part of the squadron's programme.

No. 5 Squadron's detachment at Sylt in 1952. Front row (left to right): F/O.s Amos and Horrell, F/L. Howe, S/L. Daw, F/O.s Crossley and Sheehan, P/O. Young. Back row: Sgts. Wicks and Cobb, P/O. Ward, F/O. Sturt, Sgts. Kennett and Bannard.

Parading the squadron standard on the day of its presentation in 1954. The bearer was F/O. D. C. Gathercole with Sgt. Plt. A. E. Compton and Sgt. T. W. Wilbraham as escorts; the standard warrant officer was Sgt. Plt. M. W. H. Kennett.

On December 7, 1943, the squadron was back on operations, this time at Sapam. Offensive reconnaissances over the Chindwin river areas provided its chief occupation. The move had taken no less than 12 days to accomplish by rail, road and paddle steamer. Ten railway wagon loads of equipment had to be manhandled eight times. The final stage was a 150-mile drive by a convoy of 30 three-ton trucks down the famous Manipur road.

By the middle of January 1944, the squadron was well enough established at Sapam to put up 20 operational sorties in one day—a record since arriving in the Imphal valley. In February, however, flying was reduced to a minimum since the airstrip was unserviceable owing to heavy rain.

A high spot at the time was a visit by Lord Louis Mountbatten, S.E.A.C. Supreme Commander. He was accompanied by A. Cdre. Rowley, A.O.C. 221 Group. He chatted with members of the squadron and spoke on the general war situation and prospects.

The main operations on which the squadron was engaged were night "Rhubarbs" (low-level offensive reconnaissances) and it was while these operations were in progress that No. 5 became known as "Night-lighters," because the pilots used their landing lights to illuminate the targets on the ground. How successful they were is shown by this "score card" of hits for the month of March 1944: M.T., 494; river craft, 98; locos, 4; wagons, 211; tanks, 29.

To be concluded

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By THE TECHNICAL EDITOR

EARLIER this month Avro Aircraft, Ltd., one of the chief member-companies of the Hawker Siddeley Group, conducted a significant ceremony at their factory at Malton, near Toronto. At ten minutes past three on the afternoon of October 4 the Hon. George R. Pearkes, V.C., Canadian Minister of National Defence, pulled a cord which opened wide the large curtain seen in the background to the picture on the right. Through the opening came a lowly tractor; and behind it appeared the biggest, most powerful, most expensive and potentially the fastest fighter that the world has yet seen—the CF-105 Arrow.

We in Britain have nothing like it. Two years ago we curtailed the development of a machine which would have begun to approach it—the so-called "thin-wing Javelin"—and have since relied implicitly on a superb electronic defence environment and relatively small weapons such as the English Electric P.1B and Thunderbird and the Bristol Bloodhound. Even the U.S.A. has nothing like the Arrow; yet in that country the development of manned intercepters is by no means dead. North American Aviation hold a development contract from the U.S. Air Force in respect of Weapon System 202A, which enjoys a development priority equalled by only one other U.S.A.F. aeroplane. The vehicle for this weapon system will be the F-108, a chemical-fuel aircraft intended to reach at least Mach 5 (a scarcely credible figure).

In the face of such sophisticated defence systems as those of the U.S.A. and the NATO countries it may seem surprising that Canada should pour out literally hundreds of millions of dollars upon the development of an indigenous intercepter for the R.C.A.F. On a recent visit to the Dominion the writer found no shortage of Canadians who are only too eager to point out ways in which this money could be better spent—and not all of them had a commercial axe to grind. Yet when one really studies the Arrow programme it makes sound sense and gradually materializes as something which may well prove to be a very wise investment. Not only is it the only weapon which can meet the future defence requirements of the R.C.A.F. but it is also the only aeroplane of any type in the British Commonwealth which can fly at more than twice the speed of sound; moreover, it can hold its maximum speed indefinitely. Such aeroplanes are going to be of inestimable value, and one this year is worth several next year.

Considered solely as a weapon system, the chief *raison d'être* of the Arrow is to be found in the enormous extent of the area which it is designed to defend. Including her numerous water areas Canada covers no less than 3,737,923 square miles, and is thus much larger than Europe or the U.S.A. During the past five years the electronic defence systems of North America have improved out of all recognition, and there exists today a formidable barrier of long-range radars and fighter bases all controlled from a unified H.Q. in the State of Colorado, U.S.A. Yet this "infrastructure" is of no value unless the means exist to intercept and destroy any raiding bomber which might be encountered. Nothing at present available can do this, unless one is prepared to finance the cost of not merely dozens but hundreds of bases for such devices as Bloodhound, Bomarc and Nike Hercules. It is a job which calls for a big, long-range, piloted aeroplane, with a flashing performance and all the tools of the intercepter's trade.

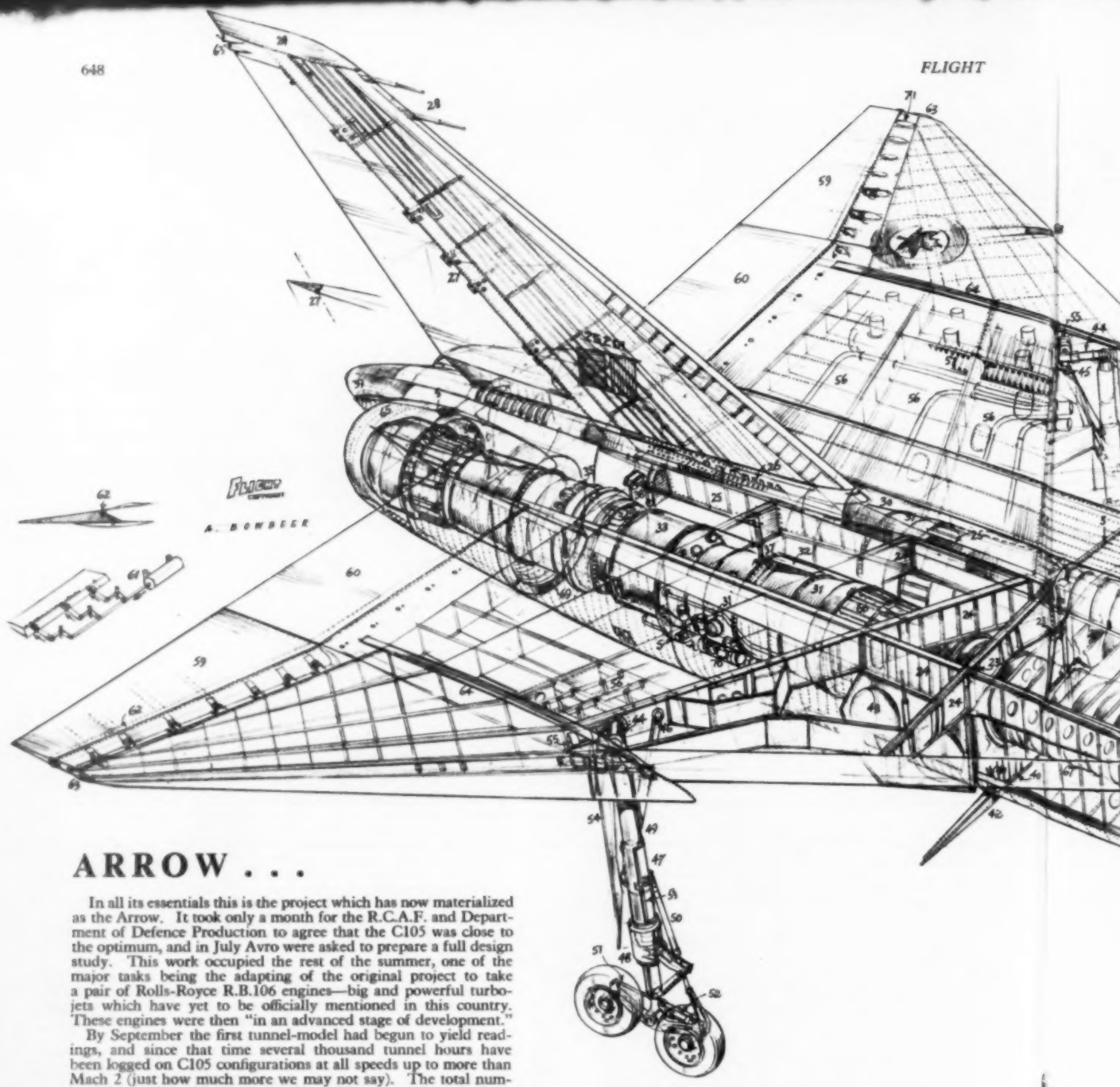
It is fitting that the mighty task of producing such a weapon should fall to Avro Aircraft, since that youthful company was responsible for Canada's first home-defence intercepter (it was also the first all-Canadian aeroplane and the Dominion's first jet aeroplane). The prototype of this machine, the CF-100, flew in January 1950. Under the impetus of Avro's dynamic president, Crawford Gordon Jr., appointed in October 1951, large scale production of the CF-100 started. Only now is this tapering off, with more than 600 of the big machines delivered to the R.C.A.F. and a substantial number still on order both for that service and for the Royal Belgian Air Force. There are some who would denigrate it; yet the success of this all-Canadian aircraft represents a tremendous achievement which has done much to instil into Canadians a long-overdue appreciation of their ability to design and build advanced aircraft fully comparable with those of America, Britain or any other country. This self-confidence must be regarded as a pre-requisite to the successful development of the CF-100's successor.

Avro began to evaluate project studies for such a successor in 1951. It was in September of that year that the company worked three possible studies into a brochure which, to start the ball rolling, was then submitted to the R.C.A.F. in Ottawa. One of the three projects faintly resembled the Gloster Javelin, with two Sapphire 4 engines. This was used by the Canadian air staff as the basis for an Operational Requirement for an all-weather intercepter capable of carrying missiles internally and—this was the real challenge—of catching supersonic bombers at high altitude.

This O.R. specification was received by Avro in March 1952. To find the optimum configuration to meet it, the company set to work on further designs. All of these employed delta wings (and, unlike the Javelin, no horizontal tail). Only by adopting the delta shape could wing depth be made sufficient to accommodate the undercarriage and the requisite quantity of fuel; and at the same time it provided ample area for high-altitude manœuvrability and permitted a fairly light and easily made structure. Finally, the Avro team chose two geometrically similar wings, and planned around them two projects, under the company numbers C104/1 and C104/2 (the C103 was a swept version of the CF-100).

Although both the C104 studies were intended to carry similar armament and to seat a pilot and navigator in tandem—Canada did not subscribe to the doctrine of the single-seat "automatic" intercepter, of the type then sponsored by the U.S.A.F.—they differed markedly in size and, to an even greater degree, in weight. The 104/1 was a design for a single-engined machine in the class of the F-106B, powered by either the Avro T.R.9 (a project which later was developed into the Orenda Iroquois), the Bristol Olympus 3 (a high-rated project intermediate between the Olympus 100 and 200 series) or the Wright J67 (an American development of the Olympus 100 series). It was to have an armament of both guided (Velvet Glove) and spin-stabilized missiles fired automatically by an advanced electronic system. The 104/2 was considerably larger—much bigger even than the Javelin—and was to have had two of whichever of the above three powerplants was selected.

Both configurations of the C104 were evaluated by the National Aeronautical Establishment in Ottawa, whose resulting recommendations were submitted in October 1952. While agreeing with Avro that the C104/2 would have higher performance and reliability than would its single-engined competitor, and was preferable on a number of other counts, the N.A.E. felt that the design as submitted could be refined to reduce weight and increase all-round performance. This was made particularly necessary owing to a number of changes in the R.C.A.F. requirement, the most demanding of which was an increase in the specified operational altitude. Accordingly Avro developed an improved configuration under the company designation C105. Compared with the C104/2 the new proposal was more compact and lighter, and promised to meet all the revised requirements admirably. It was submitted to the R.C.A.F. in June 1953.



ARROW . . .

In all its essentials this is the project which has now materialized as the Arrow. It took only a month for the R.C.A.F. and Department of Defence Production to agree that the C105 was close to the optimum, and in July Avro were asked to prepare a full design study. This work occupied the rest of the summer, one of the major tasks being the adapting of the original project to take a pair of Rolls-Royce R.B.106 engines—big and powerful turbojets which have yet to be officially mentioned in this country. These engines were then "in an advanced stage of development."

By September the first tunnel-model had begun to yield readings, and since that time several thousand tunnel hours have been logged on C105 configurations at all speeds up to more than Mach 2 (just how much more we may not say). The total number of tunnel models constructed was 17, ranging in scale from 1/80 to 1/6, and these were tested chiefly at the N.A.E., at the Langley Aeronautical Laboratory of the N.A.C.A. and at the Cornell Aeronautical Laboratory. Nevertheless, even the excellent facilities thus made available could not fully explore the whole flight envelope of the C105 without introducing complications and possible inaccuracies. To fill in the gaps Avro established a programme of free-flight model testing, using ballistic air-dropped models and large-scale models with solid-propellant boost motors. Nine of the latter were fired at the range of the Canadian Armament Research and Development Establishment at Port Petrie, Ontario, and two more were tested at the N.A.C.A. Pilotless Aircraft Research Station at Wallops Island, Virginia, the work occupying from December 1954 to January of this year.

During 1954, when the preliminary design was complete, the R.C.A.F. adopted the CF-105 designation, and the whole project moved into the detail stage. Configuration was fixed in a form which has only altered in minor details since, and the complete CF-105 weapon system was planned, with Avro acting as the prime contractor for all of it (thus breaking new ground in Canada). But progress was soon retarded by the prospect of unavailability of the R.B.106 engine, and Avro turned back to the Wright J67—only to learn from the U.S.A.F., early in 1955, that the J67 would also not be ready to meet the CF-105 schedule. It was finally decided that the CF-105 would have to be developed in two versions. The Mk 1 was planned as an intermediate development machine, powered by a pair of Pratt and Whitney J75s. The Mk 2 was foreseen as the definitive operational machine, with two of the more powerful Orenda PS.13 engines (since named Iroquois).

During 1955 an engineering mock-up was built, and almost at once it was changed to accommodate the Pratt and Whitney engines. This mock-up was evaluated by the R.C.A.F. in February 1956 and on the same occasion a mock-up of the armament pack then envisaged was assessed. By 1956 the mock-up was again being worked upon, first in order to fit it for the Iroquois engine and later in order to convert it completely to the configuration of the Mk 2 aircraft. This had to be done relatively early in order to permit all necessary modifications to be incorporated in the Mk 2 engineering-release.

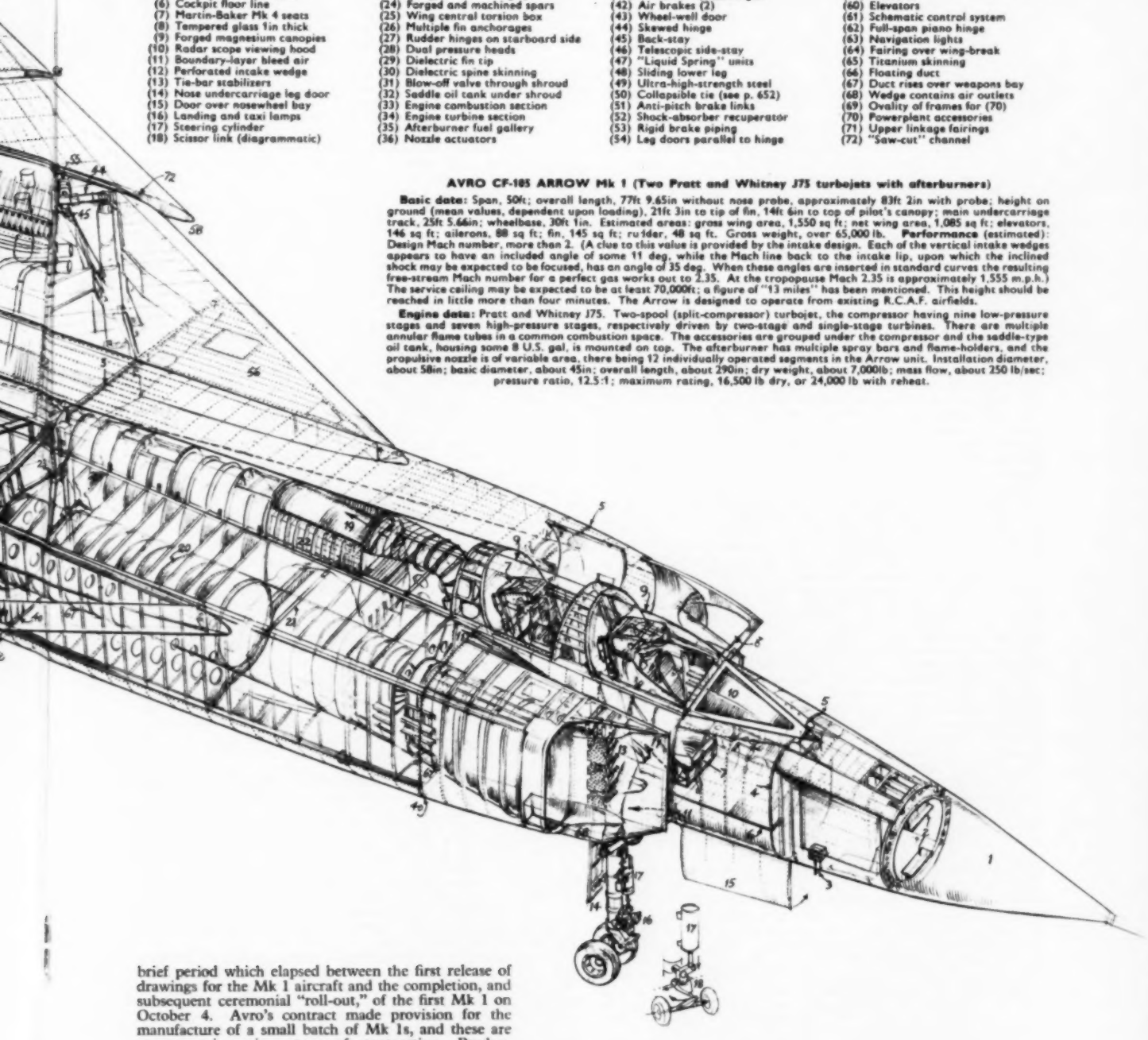
Illustrated in a diagram on page 650 is the remarkably rapid progress of the CF-105, and it particularly emphasizes the

(1) Dielectric nose-cap
(2) Scanner mountings
(3) Ice-detection unit
(4) Electronics bay doors
(5) Production break-lines
(6) Cockpit floor line
(7) Martin-Baker Mk 4 seats
(8) Tempered glass 1in thick
(9) Forged magnesium canopies
(10) Radar scope viewing hood
(11) Boundary-layer bleed air
(12) Perforated intake wedge
(13) Tie-bar stabilizers
(14) Nose undercarriage leg door
(15) Door over nosewheel bay
(16) Landing and taxi lamps
(17) Steering cylinder
(18) Scissor link (diagrammatic)
(19) Air-conditioning discharge
(20) Frames assembled on ducting
(21) Weapons bay bracing tubes
(22) Integral fuel tank
(23) Wing/centre fuselage joint
(24) Forged and machined spars
(25) Wing central torsion box
(26) Multiple fin anchorages
(27) Rudder hinges on starboard side
(28) Dual pressure heads
(29) Dielectric fin tip
(30) Dielectric spine skinning
(31) Blow-off valve through shroud
(32) Saddle oil tank under shroud
(33) Engine combustion section
(34) Engine turbine section
(35) Afterburner fuel gallery
(36) Nozzle actuators
(37) Engine front mounting
(38) Engine rear mounting
(39) Braking parachute box
(40) Weapons bay limits
(41) Armament-pack hinges
(42) Air brakes (2)
(43) Wheel-well door
(44) Skewed hinge
(45) Back-stay
(46) Telescopic side-stay
(47) "Liquid Spring" units
(48) Sliding lower leg
(49) Ultra-high-strength steel
(50) Collapsible tie (see p. 652)
(51) Anti-pitch brake links
(52) Shock-absorber recuperator
(53) Rigid brake piping
(54) Leg doors parallel to hinge
(55) Main retraction jack
(56) Integral fuel tanks
(57) Machined skin panels
(58) Conical camber and "dog-tooth"
(59) Ailerons
(60) Elevators
(61) Schematic control system
(62) Full-span piano hinge
(63) Navigation lights
(64) Fairing over wing-break
(65) Titanium skinning
(66) Floating duct
(67) Duct rises over weapons bay
(68) Wedge contains air outlets
(69) Ovality of frames for (70)
(70) Powerplant accessories
(71) Upper linkage fairings
(72) "Saw-cut" channel

AVRO CF-105 ARROW Mk 1 (Two Pratt and Whitney J75 turbojets with afterburners)

Basic data: Span, 50ft; overall length, 77ft 9.65in without nose probe, approximately 83ft 2in with probe; height on ground (mean values, dependent upon loading), 21ft 3in to tip of fin, 14ft 6in to top of pilot's canopy; main undercarriage track, 25ft 5.66in; wheelbase, 30ft 1in. Estimated areas: gross wing area, 1,550 sq ft; net wing area, 1,085 sq ft; elevators, 146 sq ft; ailerons, 88 sq ft; fin, 145 sq ft; rudder, 48 sq ft. Gross weight, over 65,000 lb. **Performance** (estimated): Design Mach number, more than 2. (A clue to this value is provided by the intake design. Each of the vertical intake wedges appears to have an included angle of some 11 deg, while the Mach line back to the intake lip, upon which the inclined shock may be expected to be focused, has an angle of 35 deg. When these angles are inserted in standard curves the resulting free-stream Mach number for a perfect gas works out to 2.35. At the tropopause Mach 2.35 is approximately 1,555 m.p.h.) The service ceiling may be expected to be at least 70,000ft; a figure of "13 miles" has been mentioned. This height should be reached in little more than four minutes. The Arrow is designed to operate from existing R.C.A.F. airfields.

Engine data: Pratt and Whitney J75. Two-spool (split-compressor) turbojet, the compressor having nine low-pressure stages and seven high-pressure stages, respectively driven by two-stage and single-stage turbines. There are multiple annular flame tubes in a common combustion space. The accessories are grouped under the compressor and the saddle-type oil tank, housing some 8 U.S. gal, is mounted on top. The afterburner has multiple spray bars and flame-holders, and the propulsive nozzle is of variable area, there being 12 individually operated segments in the Arrow unit. Installation diameter, about 58in; basic diameter, about 45in; overall length, about 290in; dry weight, about 7,000lb; mass flow, about 250 lb/sec; pressure ratio, 12.5:1; maximum rating, 16,500 lb dry, or 24,000 lb with reheat.



brief period which elapsed between the first release of drawings for the Mk 1 aircraft and the completion, and subsequent ceremonial "roll-out," of the first Mk 1 on October 4. Avro's contract made provision for the manufacture of a small batch of Mk 1s, and these are at present in various stages of construction. Production tooling has been used from the outset and should production be ordered it will undoubtedly build up in Cook-Craigie fashion. The tooling methods adopted by Avro can be described in some detail, and are of exceptional interest; but it is appropriate first to outline the general characteristics of the CF-105 itself (the aircraft was named Arrow early this year).

Probably the most fundamental foundation upon which a designer plans a new aeroplane is the type of wing which is chosen. As already noted, Avro's preliminary design office, under Jim Chamberlain (now chief of technical design) adhered throughout to the delta. The Arrow wing is, however, in no way related to that of the other Hawker Siddeley Group deltas, the Javelin and Vulcan. The British deltas are subsonic aircraft, and the Arrow is the first supersonic design actually to be completed by the Group, the Gloster "thin-wing Javelin," Avro (Manchester) 720 intercepter, Avro 730 bomber and Avro 731 research aircraft projects all having been cancelled while in the development stage.

In the initial stages of the design Avro aimed at the very ambitious thickness/chord ratio of 3 per cent, a ratio lower than that of any Western aeroplane yet to take the air. It soon became clear, however, that the percentage would have to be allowed to rise, even if only slightly, if the main undercarriage

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units were to be stowed inside. Another figure fixed early in the design was the leading-edge sweep angle of 61 deg. Instead of drag-producing fences, Avro decided to maintain chord-wise flow by using "saw-cuts" of the type fitted to the P.1.

Tunnel testing showed that the original wing could not achieve optimum performance under conditions of high angle of attack, and progressive modifications were introduced as a result of later aerodynamic data. The chief alterations made were the incorporation of conical camber and a dog-tooth leading edge. Conical camber, briefly described in an analysis of the F-102 aircraft in our issue of April 19 last, consists of a progressive drooping of the leading edge from the root outwards, so that the tips meet the incident air at a marked negative angle of attack. It has the effect of reducing induced drag and is especially beneficial at high altitude (it is a feature of the Vulcan B.2). The dog-tooth provides a marked "kink" in the leading edge planform which creates a vortex to improve flow over the outer wings, particularly at high angles of attack, without incurring the penalties of "turbulators." The revised wing has an increased sweep-angle of 63 deg 30 min on the outer panels.

These sweep angles are enough to provide tremendous axial dimensions across the wing, and the root chord is more than 440in (for comparison, the corresponding dimension on the Brabazon was 372in). This is ample to provide a moment-arm for elevators mounted at the trailing edge, and a horizontal tail has therefore been dispensed with. Fully powered control surfaces are mounted on the wing in four sections from tip to tip, the inboard pair being elevators and the outboard controls being ailerons. Just over half way from the aircraft centre-line to the wing tip is a major structural joint between the inner wing and the outer wing; the inboard section is used as an integral tank and also accommodates the complete main undercarriage units. As a small diagram on p. 651 indicates, the wing is further sub-divided along spanwise joints, and the control surfaces are separated from the wing proper by the control boxes.

Turning to the fuselage, this can be described rather rudely as a rectangular box, roughly the same width as the hull of a DC-7 or Stratocruiser, with a narrower, needle-like nose projecting from the front. From front to rear this structure measures nearly 80ft and houses, in order, a radar fire-control, a pressurized cockpit for pilot and navigator, a fuel tank surrounded by air ducts on either side and a weapons bay underneath, and a pair of exceedingly large and weighty aero engines, complete with afterburners. At the rear, the body depth is decreased so that it can fit directly beneath the wing, and the big, swept vertical tail (the area of which was increased during Arrow tunnel-testing) is joined along the rear, upper centre-line to complete the basic airframe.

It is appropriate now to describe in some detail the tooling methods which Avro Aircraft have adopted for the Arrow, since these are of outstanding interest and break new ground in several respects. As previously noted, the shape of the aircraft was determined by extensive tunnel testing, as a result of which it was possible to determine the basic lines of the airframe with a very high degree of accuracy. These lines were then used to control the construction of full-scale master models. These masters served two purposes: first, they proved the lines by the act of splining in the templates and, second, by filling in each model three-dimensionally to the correct skin-profile, they provided an accurate pattern for the manufacture of production tooling.

Initially, all sheet-metal drawing is done on thin glass-cloth using an ordinary pen, this material having flexibility, durability and excellent dimensional stability. Master control templates, or M.C.T.s, are prepared by exposing photo-sensitized 0.051in dural sheet for 2½ min against the glass-cloth drawing (for identification purposes, M.C.T.s for the Arrow Mk 2 are tinted pink). Templates too large to be reproduced from a single drawing (the limit is 16ft × 4ft 6in) are built up from sections which are spliced together with butt-joints. Symmetrical patterns are formed by printing from both sides of a half-drawing terminated at the axis of symmetry.

Two M.C.T.s are produced, one of which is retained in an *ad hoc* library and the other is built into the master model of the part concerned. The master models are each built up on a surface-table, upon which is mounted a vertical steel column with a true square section to provide four faces from which to work. On these faces the M.C.T.s are positioned by an optical transit method and finally clamped, dowelled and riveted. When all templates have been proven, tie-rods are pushed through holes about an inch in from the edge of each template and the entire master is then wrapped in brass or bronze mesh, upon which is laid Kish Epoxy 203 or 407, a low-cost plastic with an asbestos filler which is built up to within about one-eighth of an inch of the finished surface. The final contour is achieved by applying a finish-coat of 418T splining resin, which is trowelled precisely to the template contour. This plastic is bought by Avro for about 95 cents per pound, but considerable quantities are required for each master model. When the plastic has been applied and smoothed, the contour between the M.C.T.s is determined by working over the face of the model between each adjacent pair of templates with a carefully profiled flexible wooden strip coated with red crayon on the face adjacent to the model. All high-spots stand out in red, and the facing is then scraped by hand to produce the required finish. The model is completed by the addition of station, trim, tangency and butt-joint lines.

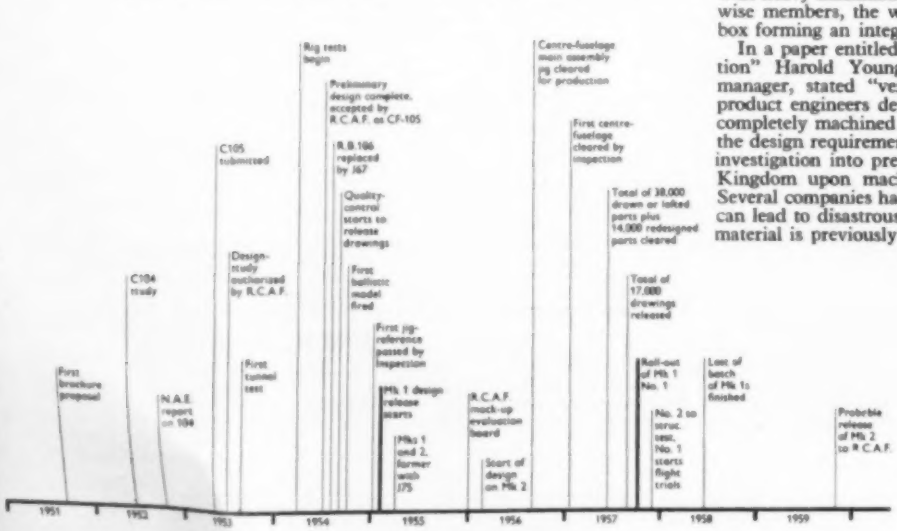
After splining the master templates, corrections may be made to the original glass-cloth drawing. Stretch-press or drop-hammer tooling can be made direct from the master, after which the first aircraft parts are brought back to the master for checking. The drop-hammer tools are generally of Kirksite, with about ¼in of cast Epoxy superimposed. Glass-cloth drill and router jigs are located directly on the master model, and rubber baskets, drill jigs and stretch moulds may also be reproduced direct from the master, a foam core being used to lighten the tools for the largest parts. Skin panels with particularly difficult contours can be reproduced by tracing from the master on to a sheet of vinyl and then developing on to the flat.

Throughout the tooling programme, preparations for production have followed immediately upon engineering-release of each detail part. Following a practice which seems to be essential if advanced aircraft are to be developed in a reasonable time, there is no prototype and the first machine built is being immediately backed up by several other Arrow Mk 1s, after which the Arrow Mk 2 follows with a very slight delay. Complete interchangeability has been achieved from scratch.

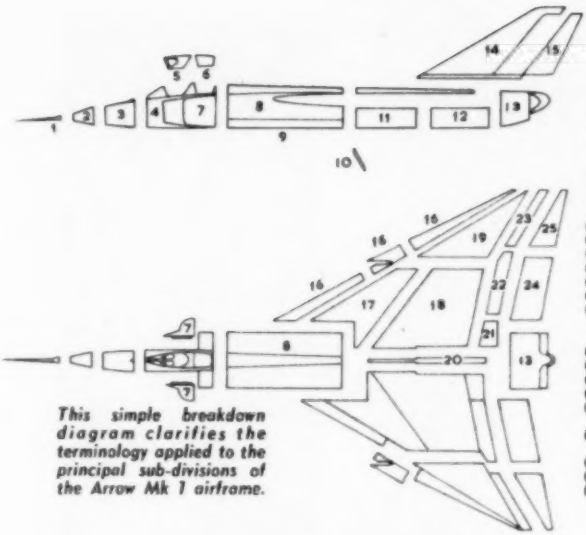
Before describing the jigging and the assembly methods followed during the erection sequence, it is appropriate to describe the airframe of the Arrow insofar as security permits. This description has been deliberately reduced in scope to meet a request by security officials in Ottawa.

Port and starboard halves of the wing-group are manufactured separately, and are joined by massive forged transverse members and bolt-rows close to the axis of symmetry. The inner wing forms the basis for the whole aircraft and comprises a leading-edge portion, a front portion, a main torque box, a trailing-edge portion (which acts as a housing for the powered controls) and the elevators. All the main sections are built in vertical jigs. The main central portion of the inner wing could be described as the backbone of the structure, and it is immensely strongly made with heavy machined skins and multiple forged spars and chord-wise members, the whole assembly being built up into a sealed box forming an integral tank.

In a paper entitled "Machining Approach to Aircraft Production" Harold Young, the company's production engineering manager, stated "very early in the design-scheme stages our product engineers determined that integrally stiffened skins and completely machined structural members were necessary to meet the design requirements." His department conducted a thorough investigation into previous experience in the U.S.A. and United Kingdom upon machining from rolled plate and solid billets. Several companies have learned to their cost that such operations can lead to disastrous distortion of major work-pieces unless the material is previously stress-relieved in a stretch-press (for which

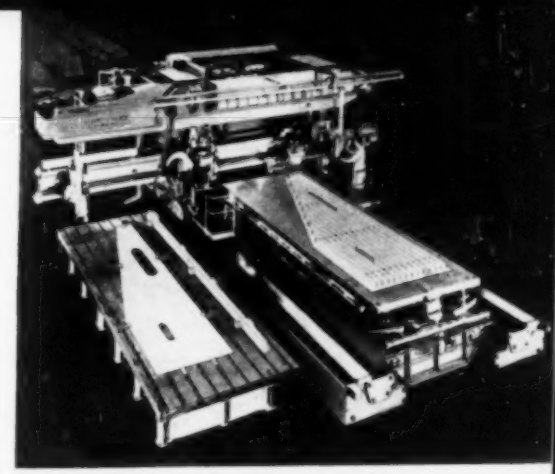

First brochure proposal
C104 study
N.A.E. report on 104
C105 submitted
Design study authorized by R.C.A.F.
First tunnel test
Rig tests begin
Preliminary design complete, accepted by R.C.A.F. as CF-105
R.B.106 replaced by J67
Quality-control starts to release drawings
First ballistic model fired
First jig-reference passed by inspection
Mk 1 design release starts
Mks 1 and 2, former with J75
R.C.A.F. mock-up evaluation board
Start of design on Mk 2
Centre-fuselage main assembly jig cleared for production
First centre-fuselage cleared by inspection
Total of 38,000 drawn or lofted parts plus 14,000 redesigned parts cleared
Total of 17,000 drawings released
Roll-out of Mk 1 No. 1
No. 2 to struc. test. No. 1 starts flight trials
Last of batch of Mk 1s finished
Probable release of Mk 2 to R.C.A.F.
1951
1952
1953
1954
1955
1956
1957
1958
1959

The diagram on the left outlines some of the important milestones in the Arrow development-cycle. Avro claim that the man-hours per pound ratio for the first Mk 1 is only about 80 per cent of the mean N. American value for comparable projects; in any case, the two thickened vertical lines are commendably close.



(1) Probe
(2) Radome
(3) Radar fire-control
(4) Front fuselage
(5) Pilot's canopy
(6) Navigator's canopy
(7) Air intakes
(8) Centre fuselage
(9) Armament pack
(10) Air brakes (2)
(11) Duct bay
(12) Engine bay
(13) Rear fuselage
(14) Fin
(15) Rudder
(16) Leading edge of inner wing, outer wing and transport joint
(17) Front inner wing
(18) Main torque box
(19) Main outer wing
(20) Wing centre box
(21) Inner trailing edge, inner wing
(22) Outer trailing edge, inner wing
(23) Trailing edge, outer wing
(24) Elevator
(25) Aileron

This simple breakdown diagram clarifies the terminology applied to the principal sub-divisions of the Arrow Mk 1 airframe.



Described in column 1 below, this Kearney and Trecker skin mill is one of the largest machine tools ever to be bought by an aircraft company. The work table is 28ft by 9ft, and a further indication of scale is provided by the operator.

purpose a stretch of some 2 per cent is required). In the basic design of the Arrow the maximum size of commercially available stress-relieved plate was limited to a cross-sectional area of 140 sq in (maximum plate thickness 3in), a value dictated by the limiting pull of 6,000,000 lb of the largest existing stretch-press. Plate thickness and cross-section may very shortly be doubled.

Avro do not inspect all the heavy plate coming in for Arrow production, but conduct spot-checks with ultrasonic reflectoscopes to determine the inclusion content. All stretcher-stress-relieved plate is received fully heat-treated and is machined in that condition. Such material is employed for approximately 85 per cent of the heavy machined portions of the Arrow airframe, the remainder being hand forgings.

The photograph above shows the 200-ton Kearney and Trecker skin mill which went into operation at Malton thirteen months ago. This is the biggest mill ever made by this famous company. It was constructed to Avro specifications and, although it cost Kearney and Trecker over $1m, Avro were charged only $350,000 and the Milwaukee company are now recovering on further sales at a price of $600,000. As used by Avro at present, the work-table is 28ft × 9ft, although extra sections can be added. In order to minimize floor-space, the table is stationary and the cutters are mounted on an overhead gantry. Basic gantry speed is 30in/min, but on a straight-through cut with rise-and-fall tracer control a feed of 100in/min is possible, while for conventional milling the speed may rise to 160in/min, and 240in/min is adopted for rapid traversing without cutting. The mighty work-pieces are retained by a universal vacuum chuck built into the table which is pivoted on a vertical axis to allow milling of tapering webs. Machining is conducted on a direct copying basis from a template, mounted on an adjacent table, across which moves a stylus with an 8-oz contact pressure; the stylus readings are transmitted to an electronic centre which releases the desired pattern to the 70-ton cutter head. The latter comprises horizontal and vertical heads, one rated at 50 h.p. at 1,800 r.p.m. and the other at 100 h.p. at 3,600 r.p.m.; both heads can tilt up to 5 deg.

To watch this mill at work is quite an experience. A typical slab of high-strength light alloy for an Arrow wing skin goes on to the work-table weighing some 3,300 lb. Using a 10in diameter cutter at 3,600 r.p.m., and employing rise-and-fall tracing for thickness-variation, it is possible to maintain a feed of 100in/min on a cut 1½in deep and 2½in wide, with a resulting metal-removal rate of 375 cu in/min. During test-runs 9ft/min was held on a cut 2¾in × 1¾in. The coolant system provides a flood-flow of over 62 Imp. gal/min in order to maintain correct tool temperatures; while, to keep the machine from burying itself in chips, the swarf roars on to a conveyor belt which feeds mobile scrap-bins. Finally the machined skin comes off the bed with a weight of 290 lb.

It is intended to supplement the giant mill by a smaller (20ft × 6ft) vertical profile miller. Unlike the skin mill the new machine will be of the planer type, with a moving table and a tracer system for rise-and-fall milling and hydraulic copying in the plane of the table. Yet another machine which Avro will install will be a development of the conventional type of router used for routing and end-milling. This machine will also accommodate skins measuring 20ft × 6ft but will be confined to finishing portions of pockets and peripheries which are perpendicular to the plane of the table. A further pair of machines which have been built for Avro are designed primarily for profile-milling integrally stiffened ribs, spars and formers. Both machines have automatic tilting heads, and to simplify template manufacture the axis of tilt has been arranged below the cutter head and can be adjusted to coincide with the mould-line of the work-piece.

Earlier it was stated that 15 per cent of the heavy machined Arrow parts are cut from hand forgings. Die forgings are not used, for a variety of reasons. As an illustration of the problems involved it is possible to cite the case of a typical wing spar, which is shown in the cut-away drawing as the only truly transverse spar. This part has a ruling web-thickness of 0.1in, and for weight-control purposes the tolerance specified is ±0.005in. As far as the writer knows, no company has yet succeeded in achieving production with die-forged parts thinner than about three-sixteenths of an inch (0.1875in), and this spar would require machining on all web surfaces. Moreover, in the quantities in which the Arrow is likely to be built, hand forging is preferred on economic grounds. Assuming a production run of 50 sets of parts, die forgings would each cost $2,980 (comprising $360 for the forging, $240 for the machining and $2,380 for the die-cost per part). Hand forging eliminates the latter factor entirely; the basic forging costs $1,279 and machining $546, making a total of $1,825—a saving of $1,155 per part.

Most of the early experience with hand forgings was achieved with 75S and 14S high-strength light alloy. With these alloys distortion during machining was prevalent, and it became customary to rough-machine down to about 0.125in or 0.25in above finished size and then heat-treat before finish-machining. Most of the Arrow parts are now being produced in the relatively new 79S alloy, which is received in the T8E13 condition and requires no heat-treatment after machining. Tests have also shown that heavier cuts may be taken with 79S while preserving the distortion-free properties. At present, however, the new alloy is restricted to hand forgings with two parallel sides not more than 6in apart and with a maximum cross-section of 72 sq in.

Another new tool which Avro have purchased for the Arrow programme is a rubber press of exceedingly advanced design which is probably the largest such tool in the world. Designed to Avro requirements by Siempelkamp, of Krefeld, Germany, the new press can exert a total force of 15,000 tons on a pad measuring 120in × 60in × 12in. Unusual features of its design are that the main frame is constructed from metal laminations arranged in groups of six, each lamination weighing 10 tons, and that the 19in working stroke is applied from below, the loading table being forced upwards into the pad.

In the manufacture of the wing the multiple machined spars and chordwise members are assembled in exceedingly accurate jigs mounted in the vertical plane. Very little of the jigging is tubular, nearly all of it being assembled from standard sections, frequently two channel-sections being mounted face-to-face to form a box with flat sides. Casting and machining is widely used throughout the jig construction and all portions are standardized in form. The larger jigs are sub-divided into portions provided with numerous accurately located pick-ups which can be set up on a surface table, the size of the portion being so chosen as to permit numerous people to work all around it. Each jig portion is completely finished to the required degree of accuracy before being brought to the final production floor, where the parts are simply assembled with practically no optical positioning or filling with low-temperature expanding alloy. The various jig portions are held together by splice plates.

Full details of the wing construction may not yet be published, but it is obvious that a considerable amount of high-strength steel is employed for all the more highly stressed portions, and in particular for all the main structural joints and root members along the spar ends. Many of the less highly stressed areas are stabilized with bonded metal honeycomb, the bonding medium being Narmco 4021 which can resist temperatures appropriate to flight at Mach numbers greater than 2. Bonding is also employed for numerous structural joints, especially those involv-

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ing the attachment of extrusions to sheet members. One field in which Avro broke much completely new ground is the bonding of magnesium alloys, which are extensively used in the Arrow airframe. Rigid control has to be applied at all stages of the bonding processes, owing to the very fine dimensional tolerances and the arduous thermal conditions under which every bond will operate in service.

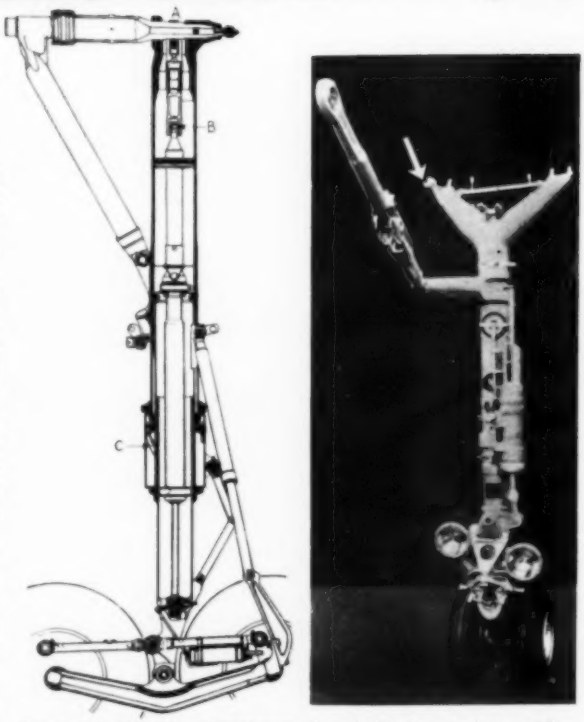
Turning to the fuselage, the structure is again sub-divided into major sub-assemblies. Several feet of the extreme nose—made by Brunswick—is formed from non-structural dielectric material (and in production aircraft will clearly serve as a radome). Continuing to the rear, the next section is obviously to be occupied by the exceedingly comprehensive search and tactical radar and fire-control system. This bay must be air-conditioned to dissipate the considerable quantity of heat generated by the equipment which it houses, and photographs show that it is enclosed by four substantial access doors which open along longitudinal piano hinges. The radar nose terminates at the front pressure-bulkhead of the cockpit. The latter is an integral part of the front fuselage, which also incorporates the intakes and the nose undercarriage.

Each of the laterally mounted intakes has a fixed geometry and is devoid of a centre-body, although the edges of the intake are exceedingly sharp. These intakes were developed with the help of the Lewis Flight Propulsion Laboratory of the N.A.C.A. and, although probably reaching peak efficiency at one supersonic Mach number, the arrangement undoubtedly has high efficiency over a very wide range of flight conditions. The inner wall of the intake is a flat vertical surface which lies some inches clear from the mould-line of the fuselage proper, the boundary layer being diverted through the resulting gap. The sharp edge of the shock-forming wedge which separates the boundary layer from the engine air has a novel interior structure consisting of small hemispheres attached to the inner and outer walls and joined to each other by rods in a manner reminiscent of molecular models.

Pilot and navigator sit in tandem Martin-Baker Mk 4 seats in a comfortable cockpit provided with an acutely raked, razor-edged windscreen and separate partially glazed canopies. The latter are of unique design in that each consists of port and starboard halves, which are hinged along their lower edges to the cockpit boundary longerons. When a canopy is shut, its two halves are locked by multiple bolts along the upper centre-line; the unit can be power-opened in clam-shell fashion for normal entry and exit of the crew. Manufacture of the canopies presented immense problems, and the material is a magnesium alloy not previously used in N. America.

Pilot vision, frequently unsatisfactory in aircraft of this nature, was perfected with the aid of a special cockpit rig. A dummy cockpit was mounted at the correct height and angle on a truck which became a familiar sight at Malton Airport. Avro's experimental test pilots, led by Don Rogers, spent hundreds of hours in consultation with the design staff responsible for cockpit layout and instrumentation, and the result—as those who have examined the mock-up can testify—is outstanding. The U.S.A.F. Director of Flight Safety, the renowned Gen. Joseph Caldara, is on record as describing the Arrow cockpit unequivocally as the best layout he had seen.

One of the complicating factors in the design of the centre fuselage is that much of the underside is broken into by a missile bay (larger than the bomb-bay of a B-29) which houses a truly immense armament pack. No details of the weapons carried may be published,* but the space available is quite remarkable, not the least impressive dimension being the width of some 10ft. The armament pack occupies the lower part of the centre fuselage and the missiles must clearly be lowered beneath the aircraft before launching. Inspection shows that the pack itself is arranged to hinge downwards about a transverse axis at its rear end immediately before the missiles are fired. It will also be noted that a detachable pack makes the Arrow inherently versatile.



Particularly difficult engineering problems had to be solved in providing the Arrow with an undercarriage. The main gear (left) by Dowty carries tandem wheels. As it retracts, eccentric A on the skewed axis pulls up linkage B, shortening the unit by 8½in; as the lower leg comes in it is turned by cam C to lie flat in the wing. The nose gear (right), by Jarry, is of equally ingenious design. The arrow points to the retraction jack pivot on the starboard branch of the "Y." When down the unit is locked and braced by the folding strut acting on the projecting arm. The photograph clearly shows the steering system.

Joining the port and starboard inner wings in their horizontal jig. The vertical jigs for constructing each half are visible in the background.

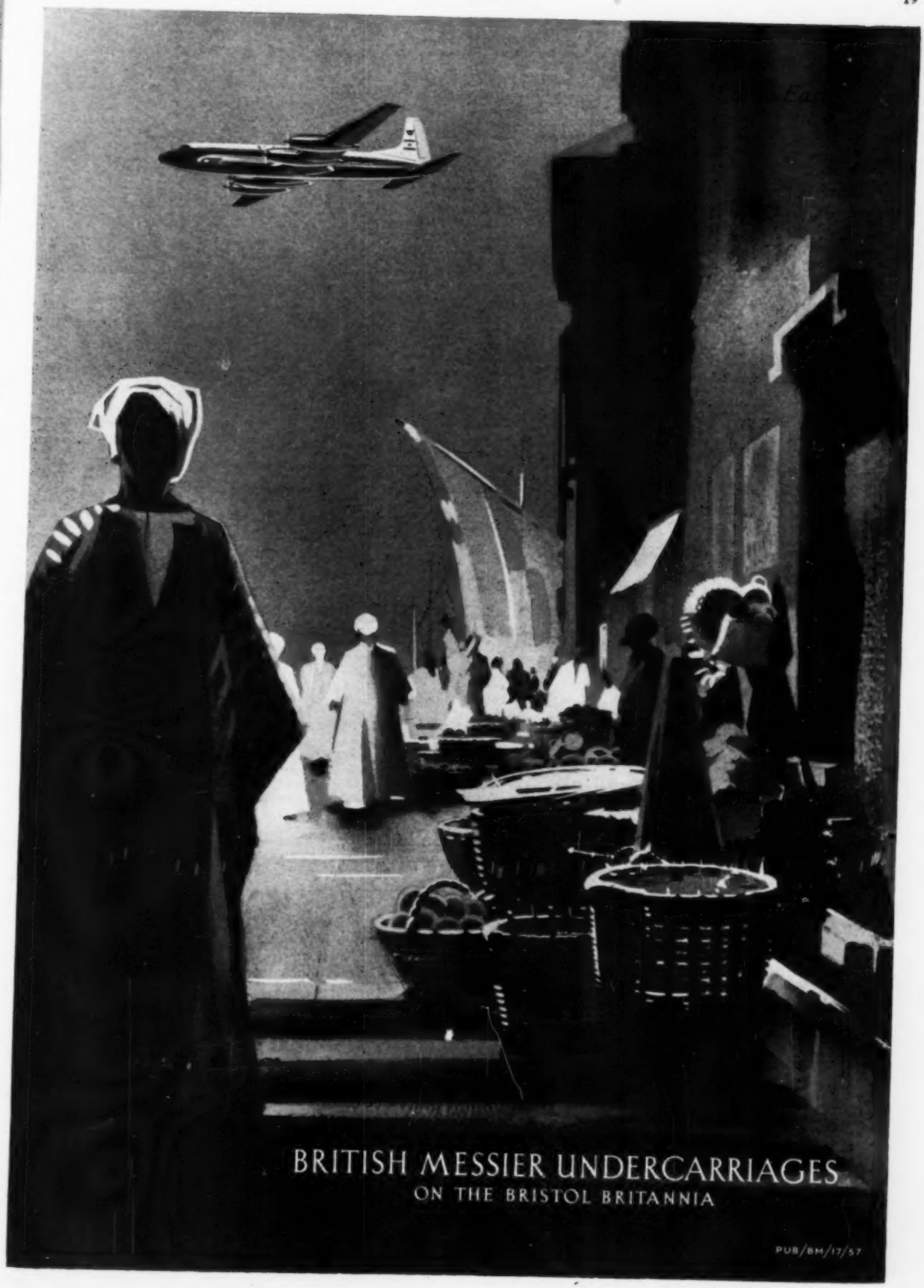
Along each side of the centre fuselage pass the engine ducts, each of roughly oval section and curving across the weapons bay. Major portions of the ducts are allowed to float axially, being restrained at one end only and locked at the other end in sliding joints. The wisdom of this unusual feature becomes apparent when it is appreciated that the Arrow may take off in air at 50 deg below zero Fahrenheit and accelerate until the kinetic heating and ram compression make the intake air well over 300 deg F hotter. The remainder of the centre fuselage—the space between the ducts above the armament pack—provides accommodation for fuel and for air-conditioning.

The next section of fuselage is known as the duct bay and, as its name implies, houses continuations of the floating ducts and joins the centre fuselage to the engine bay. Beneath the duct bay are mounted the two speed-brakes, which are very strong and unperforated surfaces hinged at their forward ends and actuated by Jarry hydraulic jacks. The engine bay itself then follows and, like the duct bay, it comprises a wide, flat-topped assembly roughly half the depth of the centre fuselage and attached to the underside of the wing by multiple bolts down each side.

These portions of the body are completely slab-sided and meet the wing at a perfect 90-deg joint with no fillet of any kind. The Avro designers were aware of the N.A.C.A. area rule (*Flight*, September 30, 1955) from an early stage in the design, and the Arrow has naturally been planned to conform to the rule insofar as it is applicable to a machine of high supersonic performance.

Between the engines the under-surface of the fuselage rises, to reduce the overall cross-section and improve maintenance accessibility. The lower rear part of each powerplant bay can be removed to provide access to the engine afterburners and hot parts (the word "hot" is only relative in the case of the Arrow) and to allow the complete powerplants to be "pulled" and replaced.

* *Several Canadian companies are collaborating in the development of Sparrow 2, a fully active radar-homing air-to-air weapon originally evolved by Douglas from the Sperry-Raytheon Sparrow family.*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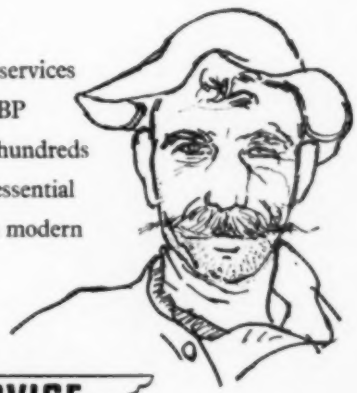

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At the extreme rear of the body is the short rear-fuselage assembly which fairs-in the propelling nozzles. In the centre is a fairing which forms the tail of the fuselage proper, and houses the braking parachute. Readily detachable to the rear as a single unit, the rear fuselage incorporates a considerable amount of titanium alloy and stainless steel, and stainless-steel blanket-shrouds are also provided around both engines.

Like the wing, the fin is of exceedingly strong multi-spar construction, and it is designed to bear immense air-loads. Each of the swept fin spars terminates at its lower end in a fork-fitting in high-strength steel, the geometry of the joint being shown by the large drawing. The joint is finally covered by a small fairing which forms a continuation of the dorsal spine. The rudder is attached at several points along a hinged axis swept at 46 deg.

As already noted, the main wing structure is separated from the control surfaces by what are described either as the control boxes or the trailing-edge members. These are immensely strong assemblies, which, by an incredible display of ingenuity, have been persuaded to accommodate all the operating jacks and control circuits for the elevators and ailerons. Avro were responsible for the design of the powered controls, and they have employed a single large jack, made by Jarry Hydraulics, for each surface.

The control surfaces themselves are attached by piano hinges extending across the entire span of each portion (a fact which emphasizes the immense strength of the wing since any appreciable bending would render such hinges inoperable). Each control surface is gapless and unbalanced, and no tabs are to be seen. Moreover, the trailing edges are slightly blunted, particularly on the ailerons, to reduce drag and flow-breakaway.

It will be appreciated that a fighter of this type, weighing more than 30 long tons and—like all deltas—with its nose high, requires an undercarriage of no mean proportions. The design of the gear was, however, complicated by the presence of the armament pack in the fuselage, which made it imperative that the entire main units should be capable of stowage inside the exceedingly thin wing. The firm which finally obtained the contract for the main gear was Dowty Equipment of Canada, and a recent paper by G. F. W. McCaffrey, their chief engineer, has highlighted some of the immense problems which his firm met and overcame. One of the greatest of these problems was the development of manufacturing processes in steel with an ultimate tensile strength of 260,000 to 280,000 lb/sq in.

Each main leg measures some 104in from the upper hinge-axis to the bogie pivot. In order to permit the entire unit to lie within the wing the leg is hung from a skewed axis and the complete gear is shortened, twisted and trimmed during the retraction cycle. Twin wheels are used on each leg and, unlike the CF-100, these are arranged in tandem in order to restrict the complete unit to the very limited depth available inside the wing. The centre of the bogie beam is pivoted to a tubular member which is restrained against vertical movement by a Dowty Liquid Spring shock-strut.

Upon landing, the rear wheel makes initial contact with the ground and rotation of the bogie beam is then resisted by tension in the collapsible tie member. Accordingly, the Liquid Spring closes, and the vertical velocity of the front wheel is held to the rate of descent of the aircraft, rather than twice this value. During retraction, the torque-carrying members of the gear are disengaged, thus allowing the whole bottom part of the undercarriage to rotate through some 40 deg under the action of a cam while linkage from the pivot cross-shaft pulls up the lower part of the leg through a distance of some 8½in. Horizontal loads are resisted by a telescopic side-stay which also contains an internal lock to hold the unit in the down position. The back-stay is not telescopic, and it is worth noting that it was the forward (anti-drag) loading on the leg which designed the structure in bending. Wheels and brakes on the Arrow Mk 1 are by Goodyear. Rigid pipe, employing swivel joints and trombone slides, is used for all braking piping, and twin brake-links prevent pitching.

One could write a book on the work which Dowty had to do to turn this undercarriage into a production job. The basic material for the main outer leg, the sliding member, the bogie beam and the back-stay are all forged in the company's Dowcan 110 ultra-high-strength steel (which approximates to S.A.E. 4340). The largest forging, the main outer leg, initially weighs about 1,000 lb; machining reduces this value to 167 lb in the finished state. The bogie beam, although smaller, is particularly tricky in view of the fact that it has a complex shape with material in three mutually perpendicular directions. U.H.T. steel bar is also used for the operating sleeve, the cross-shaft, the side-stay and several smaller details. Carbide tools are widely used for machining in the heat-treated state, and both cadmium and chromium plating is employed (both processes requiring tremendous research programmes). It is worth noting, incidentally, that the U.S.A.F. Wright Air Development Center prohibit cadmium plating on parts heat-treated above 200,000 lb/sq in. Yet another relevant factor is the incidence of static fatigue in U.H.T. steel parts, although Dowty believe that by the time the aircraft has been built and prepared for its first flight static fatigue would either have already occurred or no longer be a problem.

During the design of the Arrow gear an absolutely rational stress analysis on derived loads had to be investigated, owing to the dynamic interaction of the flexible undercarriage and flexible wing. It involved seven or eight times as many calculations as were necessary when the company designed the undercarriage of the CF-100. Extensive drop-testing was necessary to prove both the behaviour of the main gear and the performance of the Liquid Spring shock absorbers for both the main and nose units.

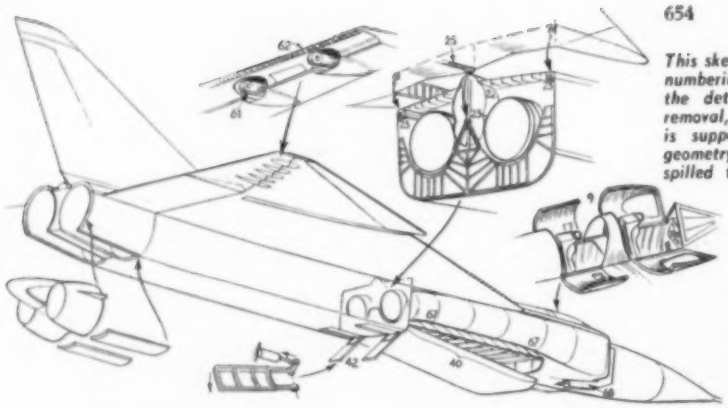
Principal contractor for the nose gear is Jarry Hydraulics. Like Dowty's main legs, the nose gear is manufactured in U.H.T. steel, the members being machined from heavy forgings. At the upper end of the leg a Y-junction and diagonal arms lead to the widely spread hinge axes, the assembly being joined by four submerged-arc welds. Levered suspension is used to compress the Dowty Liquid Spring, and wheels and tyres are by Dunlop.

Particularly worthy of note is Jarry's patent steering geometry, which employs a vertical jack and bell-crank to which is hinged the upper half of the main scissors-linkage, which in turn moves the lower half of the scissors via a ball joint. Except for the piston, the steering system is of light alloy and it operates at the full pressure of the hydraulic system. The complete assembly retracts forwards. The nose unit has undergone cyclic retraction tests, using electric heaters and dry-ice packs to simulate specified extremes of temperature. Very successful drop testing—with a complete absence of shimmy—has been carried out against Jarry's 12ft-diameter drum, which can be spun up to a simulated speed of 200 m.p.h., well above the Arrow touch-down speed.

Jarry have also conducted extensive research into high-temperature hydraulic systems. In special applications they are producing units in which the ends of actuator rods remain at 880 deg F, ambient temperature being 550 deg F and fluid temperature being 450 deg F. Sealing materials and shapes have been developed largely at their own expense, and they are well advanced in systems capable of operation from −65 deg F up to the temperature limits of the Arrow. All indications seem to suggest that the Arrow Mk 1 should be capable of reaching its performance boundaries while still using MIL-5606 fluid.

Virtually all the systems of the Arrow are subject to security restrictions, and no quantitative data may be given. It is, however, possible to comment on the air-conditioning system, for which the contractor is AiResearch. Included in this circuit is the largest stainless-steel heat exchanger yet developed for airborne use (the choice of material being dictated by the arduous bleed-air conditions). Development of this heat exchanger has spurred a complete family of related units, all of which utilize plate and fin construction assembled by a new vacuum-brazing technique to give homogeneous bonds devoid of impurities. Downstream of the heat exchanger is an AiResearch cooling turbine which feeds the cockpit; other items developed by AiResearch include five oil coolers, two actuators and an electronic temperature control. Avro, however, make all the air-

A recent view of Bay 1 at Malton, showing (front to rear): the final "marry-up" jig; a row of Mk 1 centre fuselages; a complete Mk 1; and the metal mock-up, by the exit door.



This sketch is complementary to the drawing on pages 648-9 and the numbering follows the key to that drawing. Points worth noting are the detachable rear fuselage and under-surface for powerplant removal, aileron hinge and linkage, the manner in which the fuselage is supported by the wing, air-brake operation, armament-pack geometry (problematical), discharge from the intake wedges of air spilled through the wedge perforations, and canopy arrangement.

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conditioning ducting, and this considerable undertaking has been eased by the employment of plastic tooling for these components. Avro describe the "output" of the refrigeration system as "sufficient to generate 23 tons of ice a day."

As already noted, virtually the entire wing forms an integral tank for the conventional kerosine-type fuel. The heavy boundary members around the periphery of the fuel space in the wing are provided with a continuous groove of basically circular-segment section which runs along all the faces which form butt-joints with the skin. The tank bays are then rendered fuel-tight by the injection of sealant into these grooves. It has been determined that, for an effective seal to result, the gap between the adjacent surfaces of all tank-joints must not exceed 0.003in before the sealer is applied. Notwithstanding the employment of the matched contour template system, such tolerances are virtually impossible to hold, and final matching on assembly can be achieved only by local metal removal or build-up. The former method is preferred, and it is accomplished by machining all spanwise members to their correct size and leaving a wedge of material on the chordwise ribs where the latter are joined. The amount of metal left on the chordwise members rises to as much as 0.02 to 0.03in and falls away to zero some 5 or 6in from the join. The bleeding is performed with a portable sander.

It would be logical to conclude that Avro have had to undertake extensive research into the technology of fuel systems for supersonic flight. In particular the depth of the Arrow wing is very small compared with its area, and, in spite of the fact that the skins are relatively thick, the fuel temperature is likely to stabilize fairly rapidly at something like 200 deg F when the aircraft is operating at full power. Photographs do not give evidence of a probe for flight refuelling. The fuel-contents system is by Minneapolis-Honeywell and is fully transistorized. The maximum fuel-flow exceeds one-quarter-ton per minute.

As already noted, Avro are making a batch of Arrow Mk 1 aircraft, all of which are in existence at least as major details. All will have two Pratt and Whitney J75 turbojets with afterburners. The second airframe to be built is being very fully instrumented and will be employed on structural testing. The aircraft recently "rolled out" was the first off the line, and the rest of the Mk 1s should fly within the next few months.

In view of the singularly massive nature of the Arrow airframe it is desirable to describe the principal sequences in the erection of the aircraft from its major sections. The work really begins with the assembly of the inner wing, the central torque-box being built up from fore and aft, port and starboard quarters. The aft sections, forming complete integral tanks, have heavy machined skins. To the latter are then attached separate leading edges.

The inner wing is then used as a platform upon which the rest of the aircraft is assembled. First to be put in is the centre fuselage, which is rolled up at trolley height (appreciably lower than the position it will occupy when the aircraft is finished). The next part to be brought up is the complete inner wing itself, which weighs some four tons. When fully bolted-up, the inner wing is offered-up to four jig pick-up locating points which ride in vertical slots in matching portions at the tips of the wing box. Each pair of mounting pick-ups is joined by a fore-and-aft beam which is raised by hydraulic jacks and takes the whole weight of the wing. The next step is to raise the centre fuselage and locate it correctly under the wing. When the "marrying-up" has been accomplished the structure is largely completed by the addition of the duct bay, the front fuselage, the fin, the control boxes and control surfaces, the engine bay and the main undercarriage.

Oil is then drained from the four rams upon which the wing tips are resting, and the aircraft is lowered on to its main undercarriage. A special jack is provided to carry the nose of the aircraft; this jack is mounted on longitudinal rails and pulls down the nose-gear pivot sufficiently close to the ground for the rear end of the fuselage to be raised away from the jigging. The aircraft is then moved out forwards until completely clear of the jig, when it is tilted and the stalky nose undercarriage attached to its machined-steel pivots.

A deep pit has been dug in the floor of Bay 1 at Avro's factory at Malton in order to allow the Arrow to undergo systems-testing, including nose-undercarriage retraction, with the aircraft in level-flight attitude. Engine ground running is being carried out with the assistance of a row of large silencers which, although used principally by the lower-powered CF-100s, are also suitable for the big J75s of the Mk 1 Arrow. Water cooling is provided in the sound suppressors for use during afterburning runs.

In the final-assembly state the Arrows make a striking and bold picture, resplendent in a green protective skin of strontium chromate and festooned with cables, test leads, bright yellow trestling and a hive of men who do their best to prove that Canadians enjoy bright colours. As already noted, almost the entire skin is light alloy, although it must obviously operate close to its thermal limit at some 275 deg F. Parts of the nose are made in spot-welded stainless steel, and most of the structure along the spine is of titanium, since it is heated by the discharge from the air-conditioning system. The total weight of titanium in the finished aircraft is approximately 600 lb—a substantial figure, yet less than one per cent of the gross weight.

The first Arrow is at present undergoing an intensive pre-flight test programme and is expected to fly at Malton near the end of the year. For the very good reason that there is probably nowhere else in Canada where the Arrow could be based during a flight-test programme it is probable that all the early flying will be done at Malton—in spite of the fact that it is a busy civil airport close to built-up areas and to the city of Toronto itself. Extensive telemetering is to be used during the flight development, and all signals received from the aircraft will be processed in a large vehicle—painted in the company colours of blue and gold and representing an investment of $350,000—which produces magnetic tape for the company's numerous electronic computers, chief of which is a big I.B.M. 704 installation. This vehicle is at present based on the airfield at Malton but would probably accompany the Arrow wherever it might go.

It is likely to be several months before Avro complete the first Mk 2 Arrow. This all-Canadian aircraft will differ in several respects from the Arrow Mk 1, particularly in that the Iroquois engines—lighter and more powerful than the J75s—will be installed as true supersonic powerplants with ejector-type nozzles inducing a very high airflow over the engines themselves (*Flight*, September 6, p. 413).

Future operational Arrows will be equipped with an exceedingly advanced electronic weapon system, named Astra I. This embraces search, automatic flight, fire control, navigation and communication; it is being developed by the Radio Corporation of America and the Minneapolis-Honeywell Regulator Company, and subcontracts on behalf of Astra have been awarded to R. C. A. Victor in Montreal, Honeywell Controls in Toronto and Computing Devices of Canada at Ottawa. Many other contracts have been placed for ground-support items which complete the Arrow weapon-system. Very little of the existing R.C.A.F. hangar and apron equipment can be made applicable to the Arrow, and a joint Avro/R.C.A.F. maintenance engineering group has had to design over 200 different pieces of Arrow ground equipment. The starter truck, for example, contains a gas-turbine powerplant, and the ground-conditioning truck can maintain the Arrow's weapons and electronics at a consistent 55 deg F.

Development of the Arrow is probably the largest "aeroplane" task at present being tackled anywhere outside the U.S.A. and possibly the U.S.S.R. Nearly a year ago it was estimated that the research and development costs had reached $200m, and the pace of the work is being maintained at the high level which is essential if the project is to achieve success. Even at the height of the production learning-curve it is expected that each Arrow will cost more than $2m.

It is inappropriate to comment at this time on the Arrow's future prospects. It is designed to be an operationally flexible and versatile aircraft—it could certainly do duty as a photo-reconnaissance or ground-attack machine—and Avro are taking steps to increase its performance appreciably during the next few years. So much effort and sound engineering has gone into the programme that it deserves final success, and if the next year is passed without cancellation, then such success should be assured.

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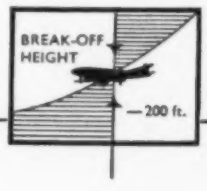

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Design Aspects of Bonded Structures

Use of Redux in the Fokker F.27 Friendship

By IR. EDW. J. VAN BEEK*

IN common with the designers of all modern civil aircraft, those concerned with the Fokker F.27 Friendship had to face some severe structural problems from the outset. The Friendship has to carry a great deal of equipment which tends to increase the weight considerably above that of the Dakota which it is intended to replace. The extra weight implied by a pressure cabin, air conditioning system, extensive electronic equipment, automatic pilot, etc., is only partially offset by the use of relatively light turboprop engines. In addition, the high-wing layout necessitates rather extensive provisions in the fuselage and wing/fuselage connections for the protection of the passengers in the case of belly landing. Every effort has thus to be made to render the primary structure as light as possible by using efficient layouts and materials with high specific strength. It is well known, however, that the use of these high-strength materials frequently leads to increased fatigue troubles and most careful attention has had to be paid to this problem. In this respect the Redux bonding process has proved to be of great importance.

Redux bonding was introduced in the Fokker factory in 1949, and since that time extensive research into the structural aspects of bonded structures has been carried out both there and at the Netherlands National Research Laboratories. Investigations have included static and fatigue tests on components and on a complete wing for a Fokker-designed primary trainer. These yielded highly satisfactory results. Based on this experience, the use of bonded structures in the Friendship was concentrated in two major applications:—

(1) Stabilization—the achievement of a stronger, stiffer, cleaner and more robust type of structure.
(2) Reduction of stress concentrations—the addition of material in critical places to increase the fatigue life.

Both these applications are extensively used throughout the primary structure of the Friendship.

Stabilization. Elimination of inter-rivet buckling and reduction of the free width of the sheet results in considerable benefit from bonding stringers and stiffeners to sheets instead of riveting.

Shear Webs. In order to determine the right dimensions of shear webs for the Friendship, the semi-empirical design method developed by Paul Kuhn and his collaborators for incomplete diagonal tension (Ref. 1) was supplemented by tests; the wing spar webs were tested in three-point bending and the curved fuselage panels in a stiff frame loaded in compression over two opposite corners. Fig. 1 shows that even after column failure of the stiffeners, the glue lines did not fail. The table gives an idea of some test results:—

STRENGTH OF SHEAR PANELS

Panel	Sheet thickn. (in)	Stiffnr. thickn. (in)	Stiffnr. spacing (in)	Height of web (in)	Ult. shear stress (lb/sq in) riveted	Ult. shear stress (lb/sq in) bonded	Mat.
I	.032	.040	5	10.5	20,700	23,900	24 ST
II	.040	.032	3	18.0	12,400	15,100	24 ST
III	.060	.048	3	18.0	25,400	29,800	75 ST
IV	.032	.032	6	18.0	8,500	9,100	24 ST

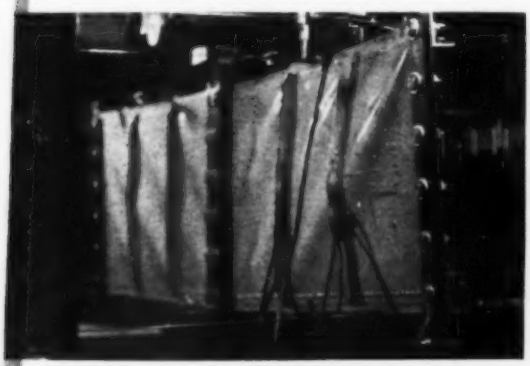
Fig. 2 shows a portion of the complete fuselage during the static tests. Diagonal tension fields are visible around the windows.

Panels in Compression. Stressed-skin-type structures have been used extensively in the Friendship, thus utilizing to the best advantage the material necessary to maintain the aerodynamic contour. The bonding of the stringers to the skin gives an additional advantage in calculation in that the influence of the rivet pitch and diameter on the strength, an appreciable factor in riveted panels, does not arise. A method of analysis was thus found by the Fokker Structural Research Group (Ref. 2) which gave both the ultimate strength and optimum configuration of the panels. In this way the upper surface of the wing was designed as an optimum structure using panels with hat-section stiffeners at a constant pitch, with variable rib-distances and tapered skins. Similar structures with lighter gauges were used for fin and tailplane. For fuselage, flaps and control surfaces, Z-section stiffeners were used. Numerous panel tests have been carried out to check the calculations.

Fig. 3 shows a heavy 75 ST panel of the optimum configuration which has exhibited an explosive type of failure at an overall stress of about 55,000 lb/sq in. A riveted panel of equal strength would weigh approximately 10 per cent more in this case.

Fig. 4 shows a lighter panel under load with well developed buckles appearing, the buckling mode between the legs of the stiffeners being different from that between the stiffeners them-

* *Chief of Structures, N. V. Koninklijke Nederlandse Vliegtuigenfabriek Fokker, Amsterdam.*



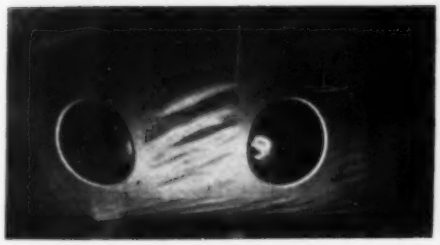
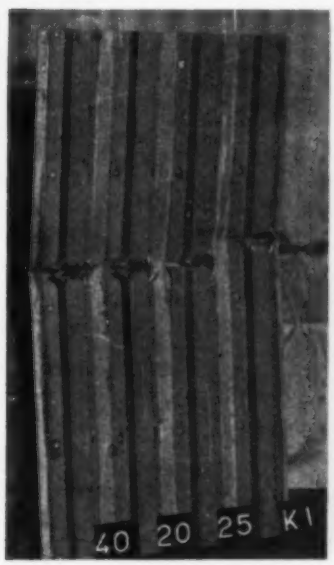


Fig. 2. Fuselage during static test, showing diagonal tension-fields round windows.

Fig. 1 (left). Shear-web tests: glue-lines intact after column failure of stiffeners.

Fig. 3 (left below). Compression test: Heavy 75ST panel showing explosive type of failure under overall stress of about 55,000 lb/sq in. *Fig. 4 (right below). Lighter panel under compression test, showing appearance of two modes of buckling.*



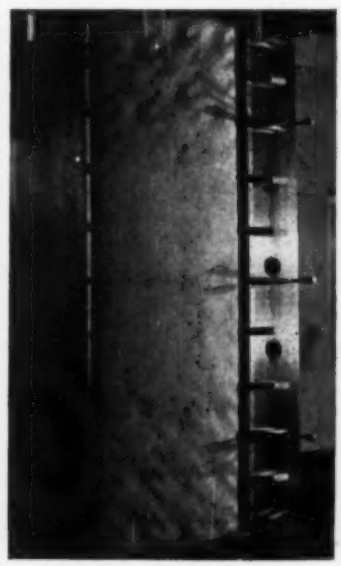


Fig. 5 (left). Fuselage panel with Z-section stiffeners under load; bonded flanges remain unbuckled. Fig. 6 (centre). Static test of complete outer wing: Failure of compression surface over length of 23ft. Fig. 7 (right). Structure of outer-wing panel seen during production.

DESIGN ASPECTS OF BONDED STRUCTURES

selves. Fig. 5 shows a typical fuselage panel with Z-section stiffeners under load. It will be seen that the stringer flanges bonded to the skin remain unbuckled, and the result is an increase in strength of up to 35 per cent compared with the equivalent riveted panel.

The result of the static test on the complete aircraft wing was simultaneous failure over a large portion. In Fig. 6 is seen a portion of the port outer wing where the compression surface has failed over a length of 23ft by instability. Fig. 7 gives a view of these compression panels during production.

Reduction of Stress Concentrations. Fatigue troubles in modern aircraft are more or less related to the increasing stress-level and the notch sensitivity which is the price we have to pay for the higher specific strength of the material, especially light alloy. Many designers are nowadays so afraid of this phenomenon that they revert from the high-strength zinc-bearing alloys to the old copper alloys without realizing that the fatigue problem is more a matter of detail design than of a special material. This is emphasized by the data (Ref. 3) published by R.A.E. Farnborough. The results of fatigue tests on over 200 aircraft joints have been analysed to determine the influence of such factors as ultimate strength of the material used, zinc or copper content of the alloy and layout of the joint (one bolt, several bolts, rivets). No single definite trend was detected and the indication is that the only significant parameter is the detail design. It is also my personal opinion, based on experience in this matter, that the fatigue problem is fundamentally one of careful detail design to avoid stress concentrations, and it is here that metal bonding has given us a powerful tool to solve many problems in a simple way.

Over much of the range (Fig. 8) the fatigue strength of a simple bonded lap joint is similar to that of a riveted one, since the holes in the riveted joint and the sudden change of material thickness in the glued joint both cause severe notches, although a greater overlap in a bonded joint can make the situation slightly better. For this reason, among others, skin connections in the Friendship are always riveted. The effect of such a type of stress concentration can be reduced only by lowering the stress level, and this can be achieved by a gradual increase of the cross-section or skin thickness. A riveted reinforcement will always weaken the original cross-section over the first line of rivets or bolts, resulting in reduction of the stress level for the remaining undisturbed area of the structure, because the weakest spot is always the critical one.

When the doublers are bonded to the skin a very gradual increase in thickness can be achieved without weakening the original cross section by rivet holes. The first doubler plate should never be taken more than 50 per cent of the original thickness, and where this cannot be achieved for other reasons a gradual reduction of the stress level will be achieved by using finger-type doubler plates. Many examples of this type of structure can be found in the Friendship. To illustrate the foregoing basic ideas a more detailed summary may be given of the development of the stringer connection on the tension surface of the wing.

Like the upper surface, the lower surface is a stressed-skin structure, with hat-section stiffeners, which behaves as a com-

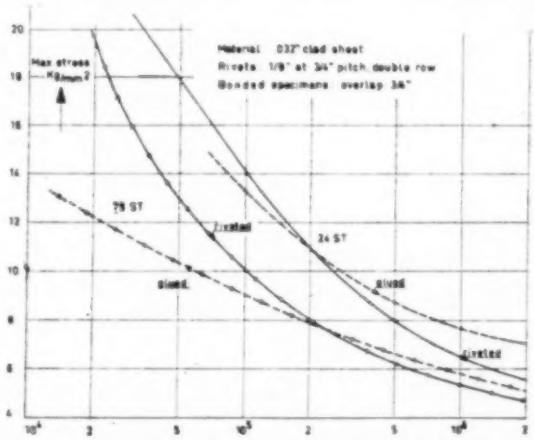


Fig. 8. Fatigue strength of lap joints in 24ST and 75ST. R=O.

Fig. 9 (below). Joint in F.27 wing, with flanges of hat-section stringers reinforced by bonded strips.

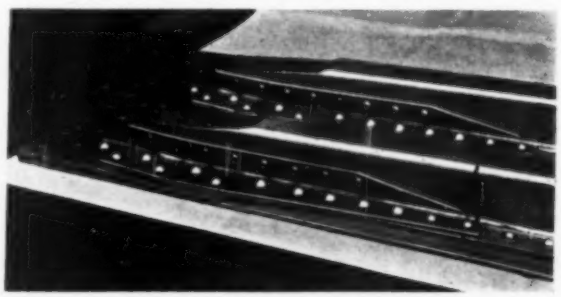


Fig. 11 (below). Joint in final form.

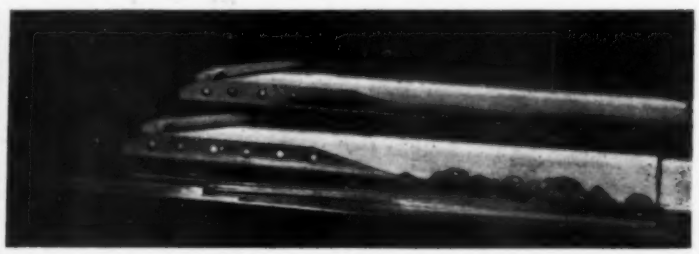


Fig. 10 (left). Arrangement of skin reinforcement in wing joint.

'A missile with a human monitor'

The new Saunders-Roe 177 Mach 2 Interceptor is powered by a fully-controllable Spectre rocket engine and a Gyron Junior turbo-jet. It is armed with Firestreak and, being a closely integrated weapons system, ensures that defence will be uninterrupted during the period leading to the unmanned missile.

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Demand for the Fokker F.27 has been strong because of the aircraft's superior ability to operate from short runways and its high payload, low block time and economical operation. Among the major airlines which have already placed orders are Aer Lingus Teoranta, Trans-Australia Airlines, K.L.M., Braathens and Philippine Airlines.

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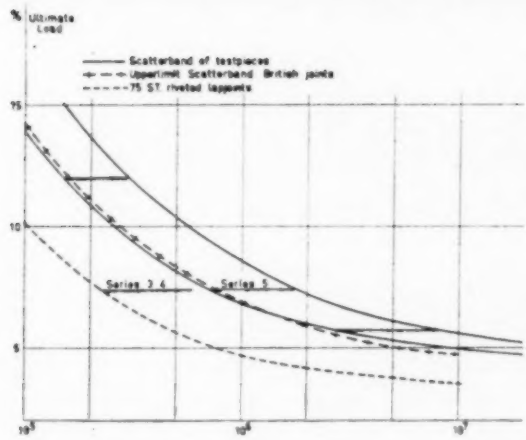

Fig. 12 (left). Scatter-band of test-pieces compared with R.A.E. results.

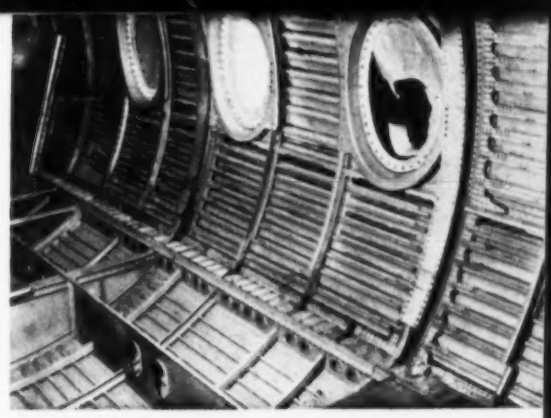

Fig. 14 (right). F.27 cabin structure in region of windows.

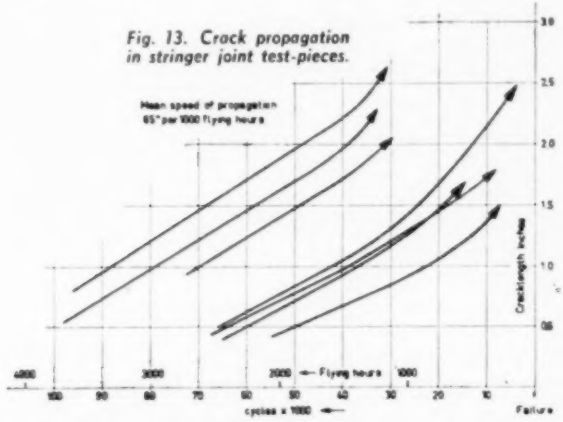

Fig. 13. Crack propagation in stringer joint test-pieces.

BONDED STRUCTURES . . .

pression surface in the negative-gust case. At numerous places—e.g., next to inspection covers and tank ends—joints are necessary to attach the stringers to equivalent doubler plates. These doublers and the stringers are bonded to the skin, and it will be clear that the connection between these two is the critical point. Over a period of three years, five successive steps of development have resulted in the production joint used throughout the wing.

Perhaps at this point it is desirable to give some thought to the general design philosophy with regard to fatigue. Two general trends have been the object of extensive discussion during recent years, the safe-life and the fail-safe theories. The safe-life theory, propagated especially in Great Britain, prefers a structure with the fewest possible critical elements—which are developed by testing to such a standard that a certain safe life can be guaranteed. A typical example is the monospar wing. The fail-safe theory, favoured in the U.S., results in a structure of a high redundancy, with many parallel load-carrying elements and crack-stopping properties. If a typical element fails in fatigue, the remaining structure should still be capable of carrying a reasonable percentage of the ultimate load, and the crack should under no circumstances propagate in an explosive way. An example is a stressed-skin structure with crack-stopping properties.

There is less difference between these two approaches to the fatigue problem than one might think. No method can guarantee with absolute certainty that a fatigue crack will never develop, but a joint designed according to the safe-life theory will have at least such a shape and stress-level at the critical points that a crack will develop very slowly in the beginning, and can be readily detected before becoming dangerous. A fail-safe structure should in any case show a certain safe life, otherwise operators would have strong objections as a result of the frequent repairs they would have to carry out. Keeping in mind that the necessary strength is in one case concentrated in one boom, and in the other in a skin with many stringers, it is obvious that the principal requirement for the fail-safe structure is basically the same as that for the safe-life structure, viz., no sudden explosive failure; or, in other words, a slow rate of crack propagation, so that damage can be detected and repaired in an early stage.

Although the design of the Friendship was fixed before the different fatigue approaches were discovered, the basic idea was understood from the beginning, and the development of the stringer joints in the wing is a good example.

The connection of the stringers to the doubler plates had to be carried out with rivets, and it was clear that the first rivet of this connection would be the critical one. Therefore the flanges of the hat-section stiffeners were reinforced by bonded strips to reduce the stress level before the connection started. After two trials the joints had the shape shown in Fig. 9, the skin reinforcement being as in Fig. 10. To increase the fatigue life still further, the reinforcing strips were doubled and after that came the idea of extending a part of the doubler plates of the skin and making them integral with these reinforcing strips. In this way the angles connecting the stringer to the doublers were reduced in size, and a joint resulted with very good fatigue characteristics (Fig. 11). Fig. 12 shows the scatter-band of the test-pieces compared with the upper limit of the scatter-band of R.A.E. joint tests and the S-N curve for single lap joints. The results are very promising, especially when the considerable amount of bending introduced by the test apparatus is considered. In the actual wing this bending is largely suppressed, and extensive strain gauge measurements on the test pieces and the wing have shown that the stresses in the latter at the critical places are about 50 per cent lower.

In combination with the tests, calculations were made in the strain differences between successive rivets in the joint, thus permitting the application of the test results to comparable stringer joints anywhere in the wing. During the tests the propagation of cracks was observed, enabling important conclusions to be drawn. As the load in a pulsator is constant, the stress in the cross-section will increase with increase in crack length. This contrasts with the situation in a complete structure, where—at least in the beginning—a constant strain will be applied, giving more favourable load conditions. Nevertheless, the speed of crack propagation was practically constant in the beginning (Fig. 13) at a value of 0.65in per 1,000 flying hours based on the R.A.E. criterion. The total developed length of one stringer being 7in, there should be ample opportunity to discover such a defect during inspection. Moreover, a stringer represents in the wing only about 5 per cent of the cross section, so it is clear that the redistribution of stresses is so small that an explosive failure is highly improbable. In this way with the help of the bonding process a type of structure can be developed which satisfies both the safe-life and fail-safe theories.

To conclude, Fig. 14 shows a part of the fuselage with another interesting point, the cabin windows. The shape of these windows is elliptical in order to form a so-called "neutral hole" under pressurization. The skin panel around the window is reinforced by a bonded doubler plate, and an extra ring is glued around the hole to reduce the stress at the attachment bolts of the window panel. The stringers between the windows are attached to fingers extending from the doubler plate.

This structure was tested separately and proved to give exactly the same strength and stiffness as an undisturbed panel without a window. In this manner the stress concentration around the window holes should be a minimum, and so again a simple solution is found, thanks to the bonding process.

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(2) G. J. Fonk: The Influence of Local Buckling on the Primary Failure of Stiffened Panels Loaded in Compression—Transactions 2nd AICMA Congress, Scheveningen 1956.
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R-THETA PROGRESS

CANADIAN CF-100 Mk 4 all-weather fighters now stationed in Europe are equipped with the Canadian R-Theta navigation computer. First shown at Farnborough two years ago, this airborne navigation device has been considerably developed and interest is being shown by a number of foreign Governments.

Both S.A.S. and Pan American are considering using R-Theta for their trans-polar flights, where the equipment offers special advantages. The latest production computers, with transistorized amplifiers, weigh 29.3 lb and the associated amplifier weighs only 7 lb. Production began in 1956. The makers are Canadian Applied Research, Ltd. (recently acquired by A. V. Roe Canada).

CORRESPONDENCE

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

Vulcan Escape Facilities

ALMOST a year has passed since the tragedy of the Vulcan crash at London Airport. The enquiries that followed revealed the vulnerability of the crew members, other than the two pilots, in an emergency. In short, they had no ejection seats by which they could have saved themselves.

Correspondence at that time showed clearly that a pilot faced with the prospect of saving himself and leaving his crew behind would have an extremely difficult decision to make. The extra time taken in reaching that decision might even jeopardise his own chances of escape.

I have read recently that Vulcans are now going into squadron service and I think it is pertinent to enquire, sir, whether all crew members now have ejection seats. It would be terrible indeed if another accident similar to that at London Airport revealed that after a year nothing had been done to provide the navigators and engineers with ejector seats.

Human error is unavoidable, but in the light of evidence from the London Airport crash it would be criminal to allow our bombers to fly without equal escape facilities for all crew members, to say nothing of the ultimate effect upon morale.

Stockbridge, Wilts. E. A. TENNANT.

[Only the pilots in any of the three V-bomber types have ejection seats. The crew escape system was prepared in accordance with official requirements stated some years ago and which must have taken into account the probability of the situation to which S/L. Tennant refers. In any case the fitting of further ejection seats would raise an almost insuperable engineering problem. We agree wholeheartedly with our correspondent's sentiment in general, though we do not feel that the effect on morale in this instance will be any more serious than it was with some marks of Meteor or the Canberra B(I).8.—Ed.].

The Cost of Keeping Veterans

THE opinion expressed in your issue of October 4 by "Ichabod" reflects the views of many who are interested in aviation history; and Dr. Ballantyne's explanation and assurance that the Nash aeroplanes are soon to be housed in a hangar, properly maintained, and on view to the public, must be a relief to us all.

With the experience we have gained in the Shuttleworth Trust of the cost of maintenance of historical aeroplanes some doubt must still be felt as to whether the problem of finding and paying a maintenance staff has not been underestimated.

The cost of rebuilding these aeroplanes to a reasonable standard for show purposes with proper provision against further deterioration may be of the order of £1,000 apiece. Assuming that a hangar is provided rent-free (?) the cost of adequate maintenance of seven historical aeroplanes, including the light and heat necessary in the hangar, must be approximately £1,500 per year. Clearly it is not worth rebuilding them unless proper provision is made for subsequent maintenance.

The problem to be faced, therefore, is still an urgent and difficult one. Where is £8,500 to come from for the first year and £1,500 to come from in each subsequent year?

Biggleswade, Beds. A. H. WHEELER,
Trustee of the Shuttleworth Trust.

The Private Pilot and I.M.C.

THE suggestion put forward recently by the Master of the Guild of Air Pilots and Navigators indicates that it is a long time since he tried to get into Croydon (or any other aerodrome in a Control Zone) on V.H.F. in foggy conditions. His suggestion for a restricted Instrument Rating for private pilots is just another corruption of the really sound proposals put forward at the symposium last February by several experienced lightplane pilots. His suggestions as to a special clearance certificate and its conditions are well-nigh a certificate to commit suicide. How many pilots are pushing up the daisies through trying to stay clear of cloud and within sight of ground in instrument conditions? A pilot is either contact or on the dials; to blend the two is inviting disaster and contrary to every tenet of instrument flying.

This Association has been formed to oppose (and very militantly if necessary) any further restrictive measures being applied to private flying, and in our expert opinion any deviation from the full Instrument Rating requirements, with regard to flying skill and ability, is dangerous. Many private pilots have a much greater background of genuine instrument-condition flying in their log-books than some of the contestants currently up at Stansted.

This problem is simple to resolve. Any pilot holding a night rating is qualified to fly in I.M.C. conditions; all that is further required to let him fly I.M.C. in Zones is a "special I.F.R. clearance." An assigned height, and an assigned heading. What could be simpler? And no additional fees or subs. to Ministry or Guild!

E. Grinstead, Sussex. M. J. CONRY,
Hon. Sec., British Aeroplane Owners and Pilots Association.

IN BRIEF

Reminiscences of the Gosport School, and of its famous C.O., Col. Smith-Barry, are sought—for inclusion in a book—by Mr. John W. R. Taylor, of 36 Alexander Drive, Surbiton, Surrey.

THE INDUSTRY

Mr. R. E. Harvey and Mr. H. G. Conway have been appointed deputy managing directors of Short Brothers and Harland, Ltd. Mr. Harvey joined the company in 1943, became general manager in 1946 and was elected to the Board in 1953. Mr. Conway joined Shorts as chief engineer in 1954 and became a director the following year. He had previously been with British Messier, Ltd., and with the Dunlop Rubber Co., Ltd.

* * *

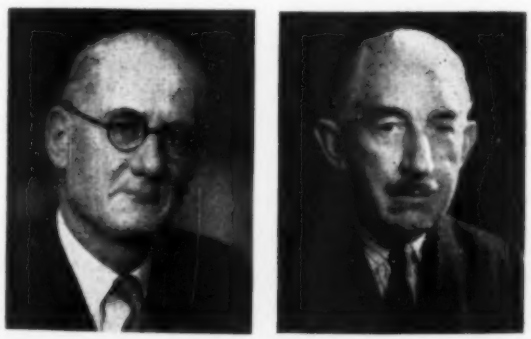
In his report at the A.G.M. of Newton Brothers (Derby), Ltd., Mr. F. V. Pipe, O.B.E., A.M.I.E.E., said that export work accounted for 19 per cent of the total production as against 12 per cent for the previous year. The company are well known as manufacturers of aircraft generators and associated electrical equipment.

* * *

We record with regret the death of Mr. William Phillips, A.C.G.I., M.I.E.E., chief electrical engineer of Elliott Brothers (London), Ltd. Aged 80, he was still active with the company at the time of his death, having joined it in 1896 and thus completed 61 years' continuous service. "W.P." (as he was affectionately known to his colleagues) had been a member of the Elliott Long Service Association from its inception in 1928 and its president since 1945.

* * *

Referring to a recent remark in these columns that the Type A5 master reference gyro made by S. G. Brown, Ltd., forms an important part of the Kelvin and Hughes flight data system, the manufacturers of the A5 ask us to make it clear that its use is not limited to this application. They state that after conception of the master reference gyro by the R.A.E. it was developed by S. G. Brown (and is now in full production) for the M.o.S.



As announced in a news-item last week, Rear Admiral Sir Matthew Slattery (above, left), chairman and managing director of Short Brothers and Harland, Ltd., has been elected a director of the Bristol Aeroplane Co., Ltd., and been appointed chairman of Bristol Aircraft, Ltd., in succession to Mr. C. F. Uwins (right) who has been appointed a deputy chairman of the parent company.

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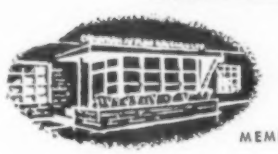
Engineered and manufactured by Canadian Applied Research Limited, under license from the National Research Council of Canada, the detection and reference probes and associated pressure switch are contained in a sealed unit, eliminating inter-connecting pneumatic tubing and reducing electrical cable requirements. Operationally proven by the RCAF and now standard equipment on the Avro CF-100 and CF-105, the ice detection system is now available to private and commercial aircraft operators. Write us for literature and quotations.

Specifications:

Size — 3⅛" x 3⅛" x 5²¹⁄₃₂"
Probes — 3" long, 5⁄16" diameter
Weight — 1¾ pounds
Power — 28 volts, 15 amps. Intermittent



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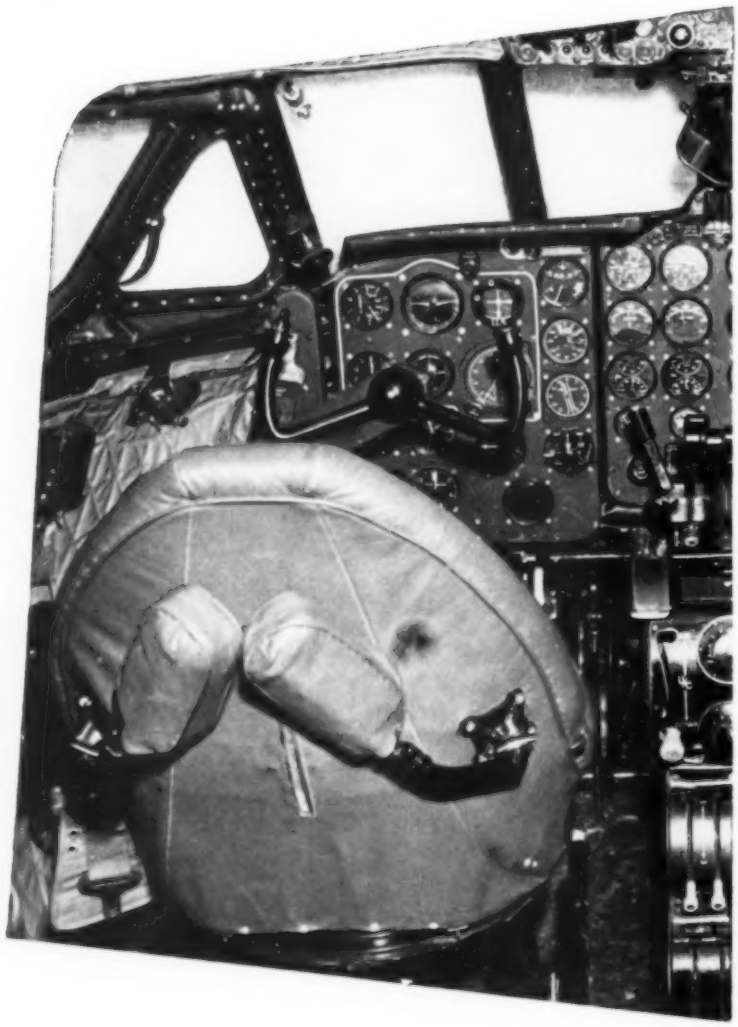

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THE ASTRONAUTICAL CONGRESS

Satellites a Topical Subject at I.A.F. Barcelona Meeting

By KENNETH W. GATLAND*

HIGHLIGHTING this year's Congress of the International Astronautical Federation, held in Barcelona, was the exciting news of the Russian satellite, though it was not a little frustrating to be rushing off to Spain on the morning of Saturday, October 5, just as the first details were coming through.

Communications with the outside world from Barcelona are not good at the best of times, and with the lines jammed by correspondents reporting the Congress little could be done but await the arrival of the previous day's English newspapers, or attempt to fathom the headlines of the Spanish Press. This dearth of information at so dramatic a moment in history resulted in a number of lighthearted rumours—one that against the rising flood of scientific acclaim for the Soviet achievement, mutterings of "utter bilge" were still to be heard emanating from the ancient towers of the Royal Observatory; and another that the Americans had shot down the Russian satellite, using their balloon-launched rocket, Far-Side.

Among the 300 participants at this year's proceedings were a number of well-known personalities in the scientific world, including Prof. Theodore von Kármán, Prof. S. F. Singer, of MOUSE satellite fame, Prof. L. I. Sedov of the U.S.S.R. Academy of Sciences, Major David Simons, the U.S. high-altitude balloonist, Mr. A. V. Cleaver of Rolls-Royce rocket-engine department, Dr. L. R. Shepherd of A.E.R.E. Harwell, and Mr. Andrew G. Haley, the authority on international law, who succeeds Dr. Shepherd as I.A.F. president.

Of great significance in view of the growing pace of astronautical development was the decision to implement a proposal of the I.A.F. International Affairs Committee to consider the legal aspects of space-flight. It was becoming imperative to establish the boundaries of air-law and space-law, said the chairman, Mr. Haley, and a working committee, comprising the best available legal and scientific minds, should be set up to draft recommendations for submission to the Secretary-General of the United Nations. It might comprise seven distinguished persons, four lawyers and three physicists, and it was proposed that Prof. John Cobb Cooper, of the Institute of Aeronautical Law, should be invited to act as chairman. Prof. Sedov was asked to suggest the names of two Soviet representatives, others to be drawn from Western Europe, the United States and South America. The proposal was accepted unanimously, and before the Congress ended Mr. Haley was able to report that Prof. Cobb Cooper had consented to be chairman.

Over 40 papers were presented at the various technical sessions, approximately one quarter of them dealing with some aspect of artificial satellites and thus having highly topical interest. One such contribution, by H. H. Koelle of Redstone Arsenal (the ex-Peenemünde group under Dr. Werner von Braun) dealt with the *Optimization of Orbital Payloads* and included some discussion on the possible nature of the Russian satellite launching vehicle. It would be logical, said Mr. Koelle, to assume that the Russians were using the powerful 264,000lb-thrust booster of their intermediate ballistic missile as the basic booster of their three-stage orbital carrier and the improved 77,000lb-thrust V-2 missile as the second stage. (The development of this combination goes back as far as 1948.) Such an approach, he suggested, was very attractive because it had the advantage of using proven hardware with established reliability. The job remaining to be done was to develop a third stage and to mate it properly with the other two, possibly using the improved Wasserfall engine of about 20,000 lb thrust. In view of the greater design latitude, all control would be incorporated in the third stage (instead of in the second stage, as in the much smaller American Vanguard rocket), which would thus have a better chance of placing the satellite in a satisfactory orbit. Disadvantages of this solution, he said, were three different propellant combinations for the missile and a total structural factor (ratio of dry weight to launching weight) which was not representative of the present state of the art. Nevertheless, this three-stage configuration would offer up to ten times the payload capacity of the first American orbital vehicle.

With the first artificial satellite already in orbit, it was natural that interest should centre on the Congress papers concerning the tracking of satellites. In a paper by Dr. F. L. Whipple and J. A. Hyrek of the Smithsonian Astrophysical Observatory, details were given of the visual search and acquisition programme, Moonwatch, and the high-precision photographic tracking programme.

Moonwatch consists of volunteer groups, each with twelve or more non-professional observers equipped with small telescopes. These telescopes, of 50 mm aperture and 12 deg field, will cover a large arc of the meridian at twilight periods during the early stages of satellite launchings and during the very last stages when the satellites finally burn out in the lower atmosphere. Nearly 100 Moonwatch teams are now active in the United States and another 50 elsewhere, in places as far apart as Germany, Spain and South America. Observers are required to note the time of passage of the satellite to the nearest second of time and its position to within a degree and transmit this information by telephone to the computation centre located at Cambridge, Massachusetts, where, on the basis of several reports, the satellite's position can be worked out by triangulation.

The photographic programme, operated by professional astronomers, centres on the use of the Baker-Nunn cameras, developed from the famous Schmidt meteor camera. Twelve photographic stations are being established, two in the United States and one each in Hawaii, Japan, India, Iran, Spain, the Netherlands Antilles, Peru, Argentine, South Africa and Australia.

A similar report, concerning visual observations of earth satellites in the U.S.S.R., was given in faultless English by attractive Mrs. A. G. Masevich of the Soviet Academy of Sciences. Like the instrument recommended for the American Moonwatch programme, the Russian observing telescope has a 50 mm aperture, with a field of vision of nearly 11 deg. There are at present 67 visual-observation stations at various places in the U.S.S.R. where suitable weather is probable.

Later, on behalf of the Soviet Academy, Mrs. Masevich presented the Spanish Astronautical Society (hosts at this year's Congress) with a beautifully finished example of the Russian instrument. A few days afterwards, at the concluding dinner, Mrs. Masevich—by now firmly established as the darling of the Congress—was presented by Prof. von Kármán with a close-fitting claret-red hat, styled as a "satellite" with decorative antenna.

Reliable estimates of the time for which close-orbit satellites will remain circling the Earth are difficult to obtain, because upper air conditions are still only vaguely known. This problem was considered in a paper by three Soviet scientists, D. E. Okhotsimsky, T. M. Eneiev and G. P. Taratynova, who have reduced it to a series of integral curves. The chart and tables thus obtained make it possible to determine rapidly the time of stay by multiplying the result taken from the table of the chart by some number which is a simple function of the basic satellite parameters. Integration of the equations was made on the fast computer of the U.S.S.R. Academy of Sciences.

A third Russian paper, by five authors, dealt with artificial satellites for the study of cosmic radiation. Details were given of recording apparatus used in these experiments, which has been developed by the Academy of Sciences and Moscow University to yield information on variations of the primary cosmic-ray intensity and in particular on the low-energy particle flux.

The future development of artificial satellites as relay stations for radio and television was considered by R. P. Haviland, of the missiles and ordnance systems department, General Electric Co., in his paper *The Communication Satellite*. The use of the satellite vehicle as a base for communication purposes above the atmosphere was originally proposed by A. C. Clarke of the B.I.S. in 1945, and in this paper Haviland examines the proposal in some detail in order to arrive at the optimum conditions for the design and operation of such services. What makes the technique so attractive is, of course, the height of operation—equivalent to a radio station having an impossibly high antenna mast. This extends the line-of-sight coverage, and makes the use of very high radio frequencies for long-range communication entirely feasible.

The more sophisticated satellites needed to perform these and other functions will require some form of attitude control (e.g., for uniform alignment of radio arrays, TV cameras, telescopes, etc.); and in a mathematical paper, R. E. Roberson (autonetics division, North American Aviation) considered the choice of the reference axis and the means of applying control torques necessary to impart sufficient angular acceleration to keep the satellite aligned with the chosen datum. One of the most promising techniques is the use of power-driven flywheels, which provide an inertial reaction torque when accelerated relative to the satellite's frame; the small electric motors required for this purpose might draw their power from solar batteries (which convert sunlight directly into electricity), thereby rendering the system virtually self-supporting.

Selenoid Satellites was the subject chosen by W. B. Klemperer and E. T. Benedikt (missiles engineering department, Douglas

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* *Mr. Gatland, who is vice-chairman of the British Interplanetary Society, was British delegate to the Congress. He is the author of the "Flight" book "Development of the Guided Missile."*

At the Congress table: (right to left) Mrs. F. C. Durant, wife of the U.S. delegate, but representing the Japanese Astronautical Society; Mr. K. W. Gatland, the British delegate; Mr. L. J. Carter, secretary of the British Interplanetary Society.

THE ASTRONAUTICAL CONGRESS . . .

Aircraft Company), who considered the case of a Moon Companion on such an orbit that it would remain in a constant aspect relationship to Earth and Moon. Such a station, it was claimed, would have properties which could become useful in any lunar satellite telecommunication system and, conceivably, for checking the Moon and Earth mass ratio.

The physical recovery of research payloads fired to great heights by research rockets, or launched into satellite orbits, was discussed by R. T. Patterson of the Glenn L. Martin Company. In many cases research information can be telemetered to the ground and the payload subsequently allowed to vaporize in the lower atmosphere, but for certain research tasks it becomes necessary to make provision for recovery. Examples of studies requiring the recovery of payloads are: primary cosmic-ray research with nuclear emulsions; geodetic, weather, astronomic and spectroscope research with photographic emulsions; and environmental research with animal tissues, structural materials and equipment. The results of this study, applied to useful payloads of 25 to 200 lb in spherically nosed bodies of 1 to 2ft diameter, falling vertically from altitudes of 2,000 miles and higher, may be summarized as follows:

(1) entrance velocities range upward from 21,000ft/sec.
(2) the useful payload must withstand decelerations of at least 109 g.
(3) total heat input to the body ranges upward from 4,000 B.Th.U.—a small part of the total kinetic energy of the system. This heat input is accommodated by allowing a part of the payload (insulating layers on the nosing) to melt. Fiberglas-reinforced phenolic resin is specified as a good insulant, which is relied upon to remove all the heat input to the body by melting. Peak heat input and deceleration occur at altitudes of 60,000ft or higher; the duration of heat input and deceleration are brief (about 10 sec), the velocities of parachute deployment and impact are moderate; water recovery is advantageous; location of the payload would be facilitated by means of an in-built beacon transmitter.

Of great fascination, in that they concerned physical investigation at the frontier to space, were two papers dealing with the successful Man-High experiment in which Major David Simons ascended by balloon to a height of 20 miles. Otto C. Winzen, of Winzen Research Inc., first described the history of the plastic balloon which his firm had pioneered, including details of the Rockoon experiments of 1952-53 whereby small solid-propellant Deacon rockets were fired from balloons to heights of 60 miles. The same rocket, when ground-launched, he said, could reach a maximum height of only 19 miles.

Project Man-High followed a series of experimental flights with animals (mice, guinea pigs and monkeys) designed to study the effect of cosmic rays at altitudes up to 126,000ft and for exposure times of up to 36 hours. In the subsequent manned experiments, one daylight flight was made to 96,000ft, using a 2m cu ft balloon; and another, in August this year, to 100,000ft—a 32-hour flight with a 3m cu ft balloon.

The sealed cabin takes the form of an aluminium capsule 8ft high and 3ft in diameter, having an artificial atmosphere of oxygen, helium and nitrogen; it is fully insulated against heat losses at night and the intense solar radiation of the daylight hours. An air regeneration system and a separate air-cooling system form an integral part of the climatic control.

In the second paper on this theme, Major Simons spoke of the importance of the balloon system in simulating many of the conditions that must be faced in a manned satellite, providing as it does an invaluable tool for gaining an insight into the human factors involved. These include a sealed cabin atmosphere, isolation, radiation heat balance, and an opportunity to observe the earth and sky from above 99 per cent of the earth's atmosphere. The many applications of this technique, he said, included the fields of space-medicine, meteorology, atmospheric physics and astronomy.

In conjunction with these papers, dramatic colour films were shown, the first depicting preparations for Project Man-High; the sealing of Major Simons in the pressure capsule, the filling of the balloon with helium, and finally the take-off from an open mine in central Minnesota. Then came the film which the balloonist himself shot from within the capsule, including the most incredible views of the Earth and space. Even so, as Major Simons remarked, the full beauty of a sunset as viewed from 100,000ft, with a thin haze of blue on the curved horizon and red and orange light striking up towards a dark purple sky, could never be adequately conveyed on film. The atmosphere was so clear that the stars no longer twinkled but appeared as bright points of light of quite remarkable intensity.

The next stage in astronautical development, that of sending an unmanned rocket to the Moon, received attention from both Russian and American speakers at the Congress. The first part of the paper by V. A. Yegorov of Moscow University was devoted to a general investigation of the initial velocities and trajectories required for lunar missions. The second part dealt with permissible errors in launching, considering first "hitting trajectories" corresponding to the various initial speeds, and second the more sophisticated circumlunar orbits allowing for return into the earth's atmosphere. It was emphasized that whereas the former objective could be achieved fairly simply without any corrective thrust being applied during the period of coasting flight, the circumlunar orbit with return to earth would involve at least one power manœuvre.

Interplanetary Ballistic Missiles—a new Astrophysical Research Tool, was the title of a paper by Prof. S. F. Singer of Maryland University, who introduced a controversial note into the proceedings by suggesting that the Moon might be used as a target for ICBMs with hydrogen-bomb warheads. The technical ability to shoot ballistic missiles at the Moon was now almost within reach and his object was to show that it was both desirable from the viewpoint of testing such weapons, and worthwhile as a scientific venture. As H-bombs became more powerful the point would soon be reached where tests on the earth might present a health hazard to the world's population. His proposal would do away with this hazard by exploding the bombs on the Moon and measuring their performance from the Earth by means of gamma-ray detectors in the high atmosphere, by light-flash as observed from the ground, and by carefully scaling the lunar crater produced by the explosion. The H-bomb race between the big Powers, Singer suggested, would then be reduced to the much more tractable problem of seeing who could make the biggest crater on the Moon.

Scientifically, he said, it was quite possible that by blasting-loose portions of the Moon and recovering them on earth for chemical study, we might learn something of the origin of the Moon by comparing chemical ratios with those of our own planet. The faster objects liberated from the Moon, the speaker said, would act as meteors and produce luminous and ionization effects in the upper atmosphere, but the larger objects, particularly those which enter with low enough velocities (corresponding to the escape velocity of the earth), might land without having lost much of their mass and without having been greatly heated.

On the whole, this paper was received with rather mixed feelings by delegates, for it clearly raises big political issues and emphasizes the need for some kind of international agreement on space-law governing the exploration and exploitation of the Moon and planets.

Unfortunately, space does not permit mention of more than a few of the technical contributions to this important symposium, and in this review I have felt it best to concentrate on subjects likely to have more immediate interest. However, first-class contributions were made on a wide variety of topics related to astronautics, ranging from the probability of intelligent life on other worlds to variable thrust control for space-vehicles, and ionic propulsion systems. All these papers are being published in full in the I.A.F. journal, *Acta Astronautica*.

I.A.F. congresses have been established as annual events, and the next will take place in Amsterdam during the last week in August next year, with the possibility that 1959 will see a meeting in Moscow.

Informal moment: (left to right) Mrs. L. J. Carter, Mrs. K. W. Gatland and two members of the U.S.S.R. Academy of Sciences—Mrs. A. G. Masevich (who is in charge of the teams tracking the Russian satellite by optical methods) and Miss L. V. Kurnosova.

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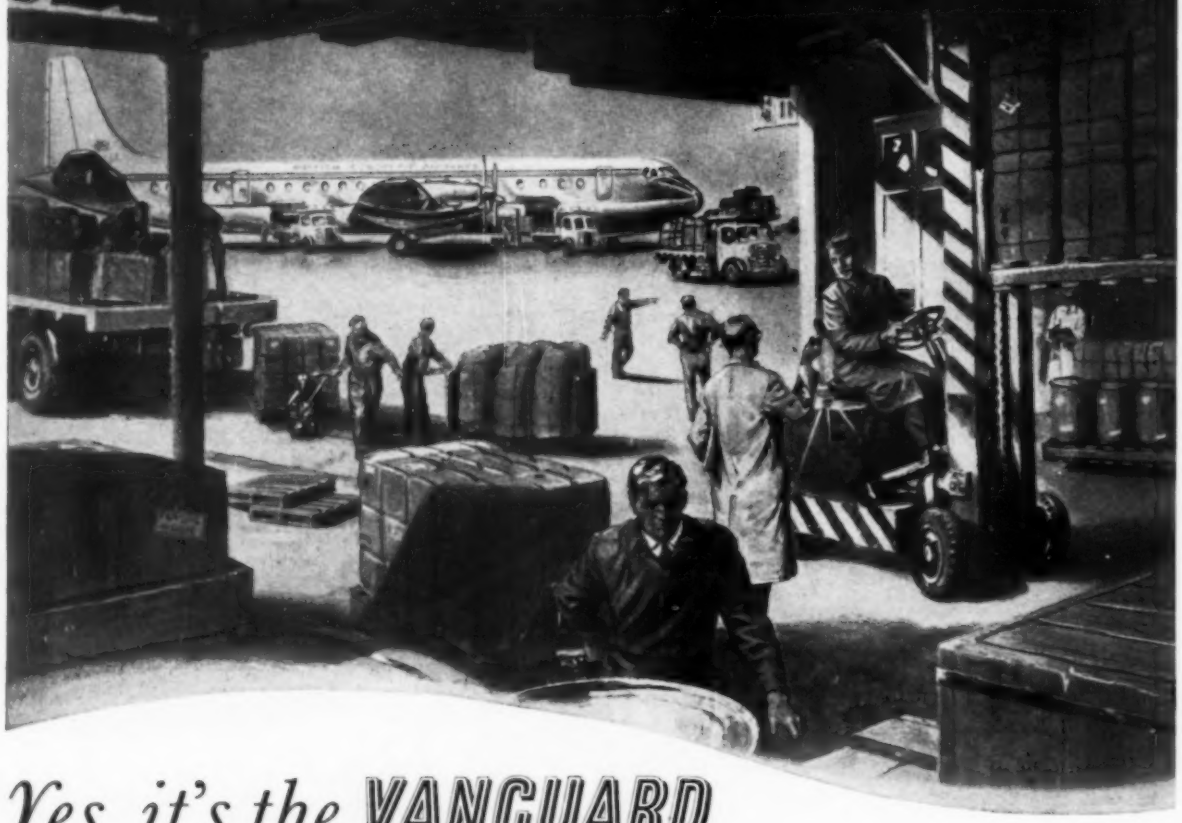

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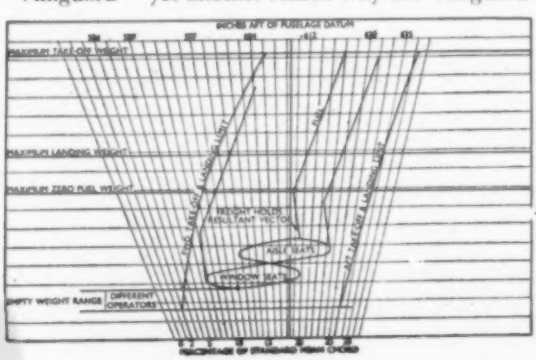

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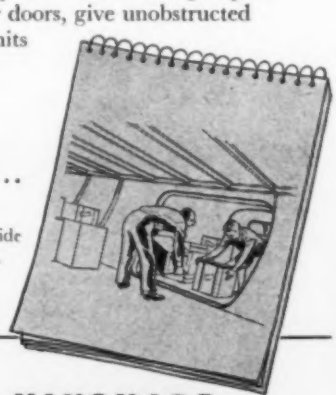

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CIVIL AVIATION

MIAMI TALKS POSTPONED

HOWEVER high feelings at I.A.T.A. traffic-fare conferences may run, the airlines have never permitted their discussions to break down, for to do so would mean that fare-fixing would pass into the hands of governments, a prospect which fills every I.A.T.A. airline with horror. Thus when points of view are widely divergent, and negotiations particularly difficult—as they have been at the recent traffic conference at Miami—the airlines (in the words of the conference chairman, Mr. Gordon M. Bain, sales vice-president of Northwest Airlines), take a breathing spell in their negotiations and attack the problem again later.

The stumbling-block at the Miami conference, as expected, has been (we quote I.A.T.A.) "practical difficulties involved in determining the service pattern for the North Atlantic route. There is no disagreement in the intention of starting the new low-fare service which was adopted by the 1956 traffic conference at Cannes; there are differences as to the conditions of this service and its relation to the other classes of service on this route." "Complete agreement" on cargo rates was, however, reached.

The conference remained in session until the end of last week to complete the remainder of the fare negotiations, but further discussions on North Atlantic fares were postponed until November 19 in Paris.

At the 1956 Cannes conference, the airlines left undecided the standards of service to be offered with the thrift-class fares that it was agreed (not without initial dissent) should be introduced on the North Atlantic in April 1958. They left open too the relationship of these new thrift-class fares to the remainder of the fare structure. But it is not the complexity of a three-tier structure, with its intricate sales and planning problems, that—not to mince words—has caused the Miami conference to be abandoned. At Cannes, the introduction of third-class fares, urged by the C.A.B., seemed to be bold, wise planning. Now the airlines, having had a year in which to measure slender profit-margins against ambitious re-equipment programmes, and having found that the C.A.B. will not grant their request for an emergency five per cent transatlantic increase, are apparently wary of introducing third-class fares on too big a scale. Although the third-class fare level is not in itself in jeopardy, resolution of the way in which it will be applied seems likely to test the cohesion of I.A.T.A. to an unprecedented extent.

VISCOUNTS ON SAFARI

AS previously recorded, Airwork and Hunting-Clan have now introduced Viscounts on to the Colonial-coach *Safari* services to East and Central Africa. The first service, which established a new and brighter era for Britain's privately operated scheduled public services, left London Airport at 10 p.m. on October 17 bound for Nairobi. The following night the first Viscount service departed for Salisbury.

Considering that neither Airwork nor Hunting-Clan had Viscounts available when the Government announced its change of policy concerning these routes last June, the two independents have been quick to get Viscount services established. Hunting-Clan, as previously recorded in *Flight*, will replace Vikings with the three Viscount 732s leased to Middle East Airlines and returned earlier this month. The aircraft have been refurbished and equipped as 53-seaters. At the present time it is not certain which Viscounts will operate in Airwork colours, but it is probable that the airline is considering the lease, for the time being, of the two Fred Olsen 736s recently returned by their lessees B.W.I.A. and M.E.A.

The fares will remain the same as the existing Viking fares, but—in order to maintain the same capacity, as specified by the government—frequency will be reduced to twice-weekly to East Africa and once-weekly to Central Africa. Thus low-fare competition with B.O.A.C.'s Britannia services will still be restricted in terms of capacity and speed (there will still be night-stops), but no longer in terms of comfort.

Restrained and elegant, as befits a royal apartment, is the interior of the DC-7C used by the Queen and the Duke of Edinburgh for their visit to Canada and the U.S.A. This fine conversion is the work of B.O.A.C.

B.O.A.C.'S BRITANNIA PROGRAMME

THE outcome of Bristol's examination of the two Proteus 755s removed from Britannia 312 G-AOVB at Miami earlier this month, and flown back to England, is that the engines—as first thought—did in fact suffer contraction of the compressor casings. It will be recalled that the aircraft had to feather Nos. 2 and 4 engines during a proving flight from New York on September 30 after experiencing a sudden change of ambient temperature. The contraction caused rubbing of the blades, and as expected, the Bristol modification has involved cropping of the blades by 0.01in.

G-AOVB's engines have been thus treated, and it is expected that within the next week the aircraft will be able to resume its programme of proving flights on the eastern seaboard of America. B.O.A.C. intend that it will be based on New York to make proving flights either to the Caribbean or north to the Newfoundland area in accordance with the Corporation's original plans.

Britannia 312 transatlantic proving flights between the U.K. and the U.S.A. will be resumed also, and there is no change in B.O.A.C.'s intention to inaugurate scheduled services "within the first three months of 1958."

The blade-cropping modification applies to all existing 755s, but not, it is understood, to the 705 engines of the Britannia 102 fleet. It seems that the compressor casings of the 755 series, having a higher magnesium content than the 705 casings, have a different expansion differential. Modification to production-line 755s was under way before the Miami experience.

Visiting Short Bros and Harland to discuss applications of Bristol engines with Shorts' chief project engineer, Mr. F. H. Robertson: (left to right) G/C. Donald Black, Mr. Neville Quinn, Mr. Gordon Lewis and, extreme right, Mr. A. Reid. Mr. Robertson is a frequent contributor to "Flight" on the subject of the turboprop and its merits.

CIVIL AVIATION . . .

DC-8 ON SCHEDULE

CONTRARY to rumours circulating within the British industry, the DC-8 programme is "on schedule to the day." The programme is unchanged from that published in *Flight* last April, *viz*: roll-out, February 1958; first flight, March 1958; start of C.A.A. tests, February 1959; first delivery to PanAm (for training) June 1959; certification and production deliveries, October 1959.

The first aircraft for PanAm is about to undergo the marriage of wings and fuselage at the Long Beach plant.

HERALD PRODUCTION UNDER LICENCE?

FROM Handley Page comes news that India is "showing increasing interest" in the Dart Herald as possible new equipment for Indian Airlines' internal routes. That operator has been giving urgent thought to the replacement of its 60-odd DC-3s, and there have been many reports from Indian sources of interest in both the Herald and the Friendship. The possibility of licence-construction of either aircraft by Hindustan Aircraft, Ltd., has been mentioned. It is understood that the Indian Government, on behalf of the Indian Airlines Corporation, is favouring the Dart Herald.

It is now reported that Australia also is interested in the Dart Herald (see *Flight* October 11) and that a proposal for the Commonwealth Aircraft Corporation to build the aircraft under licence is being considered.

UNITED'S "MEDIUM" PROGRAMME

UNITED Air Lines have now been closely watched for considerably more than a year by manufacturers with medium jets and turboprops for sale. The airline is still the only member of the U.S. domestic "big four" still to make up its mind about its medium-transport programme. For many months the strongest contender appeared to be the Electra, and United were reported a month or so ago to have allocated a sum of about $40m for an Electra fleet, indicating a fleet-size of 30 to 40 aircraft.

More recently, however, there have been rumours that United now intend to side-step turboprops and move towards an all-jet fleet. Having already ordered thirty DC-8s, the airline now intends, it is reported, to buy either Convair 880s or Boeing 717s as partners for the big jets. Last September, Mr. W. A. Patterson, United's president, was said to have made up his mind about the Convair 880; but it seems that Boeing came forward with attractive proposals regarding the Boeing 717. It is between these two aircraft that United's choice now seems to lie.

BREVITIES

JOHN CUNNINGHAM, flying the Comet 3, established an F.A.I.-recognized point-to-point record between London and Khartoum on October 16. The official distance of 3,064.1 statute miles was flown in five hr, 51 min, 14.8 sec—an average speed of 523.41 m.p.h.

* * *

K.L.M. have appointed Mr. Arnold J. Weight as regional sales manager for the U.K. and Ireland.

* * *

The Indian Government has sanctioned finance for the extension of the three existing runways at Santa Cruz airport from 8,000ft to 10,000ft by 1960.

* * *

B.O.A.C. have appointed new general managers on their western, eastern and southern routes. They are, respectively, Mr. Gilbert Lee, Mr. J. Ross Stainton and Mr. Derek Glover.

* * *

Mr. J. Bols, a senior executive of Sud-Aviation, arrived in Johannesburg earlier this month for negotiations with South African Airways about the possible purchase of Caravelles.

* * *

Viscount-acclaim from Iceland Airways mentions an increase in average load-factors from 58.4 per cent to 75.5 per cent and an increase in the number of passengers carried by 46 per cent in the first four months of Viscount operations.

Unconfirmed reports from Sweden suggest that S.A.S. may shortly take up their option on a further 14 Caravelles. They have 19 on option.

* * *

Three K.L.M. crew-members have been presented with gold medals by their president, I. A. Aler, on completion of more than 20,000 flying hours.

* * *

PanAm are to introduce a direct service from Manila to Madrid by way of San Juan, Puerto Rico and Miami. The airline's present terminal in Spain is Barcelona.

* * *

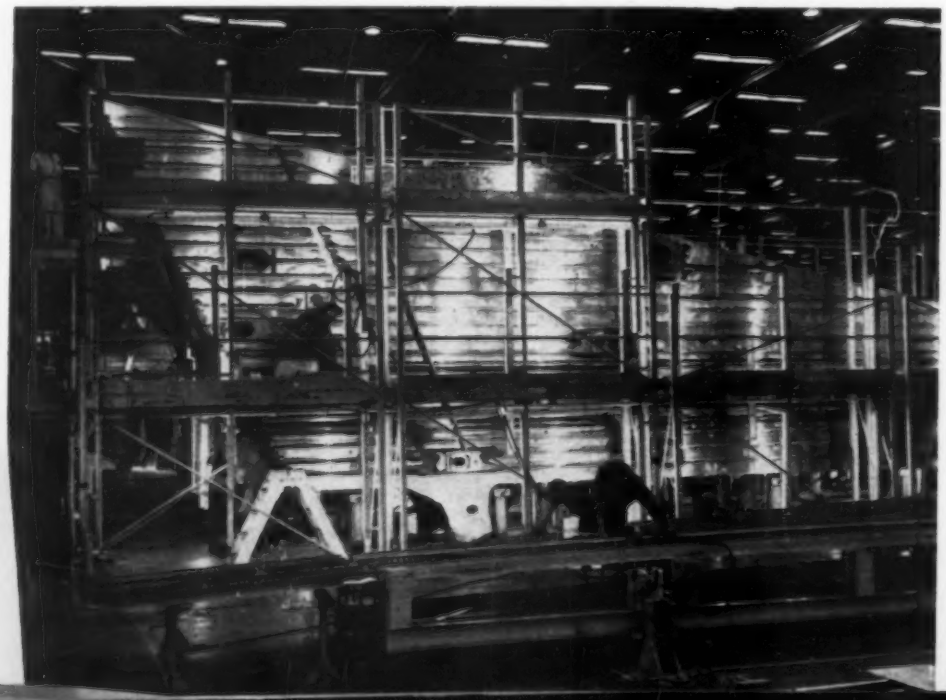
The tailplane configuration of the de Havilland D.H.C.4 Caribou has been changed from a double-fin to a single-fin unit. The production programme is said to be on schedule.

* * *

Total number of Beavers built by the de Havilland Canadian company up to September 27 was 1,131, of which 730 were L-20s for the U.S. Army. Otter production had reached 208 at that date.

* * *

On Network Three at 6.15 p.m. on October 30, in the "Younger Generation" services *This Changing World*, the B.B.C. are to broadcast a programme on electronic aids for pilots. Recordings will be made from Marconi's works at Chelmsford, at the Decca research laboratories at Hersham, at the works of Elliott Brothers (London), Ltd., Boreham Wood, and at London Airport.



Seen in the sealing shop is this integral-tank wing-skin of a production Boeing 707. Riveted stringers are used to stiffen the untapered skin between widely spaced spars.

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

At Pinecastle A.F.B., Fla, the American public takes a look at one of the Bomber Command Valiants of No. 3 Group which are participating in the S.A.C. competition.

Hong Kong Appointment

SINCE February this year A.O.C. at Air Headquarters Singapore, A. Cdre. P. D. Holder is to succeed A. Cdre. A. D. Messenger as A.O.C. Hong Kong.

A South African, A. Cdre. Holder was educated in this country (he graduated B.Sc. in civil engineering and later gained a Ph.D.) and during the war served with Bomber Command, being awarded the D.S.O. and D.F.C. One of his last appointments before going to Singapore was as Deputy Director of Policy (Air Staff).

New Unit Badges

TWO R.A.F. operational stations—Acklington in Northumberland and Akrotiri, Cyprus—are among units for which badges have been recently approved by the Queen. Acklington's takes the form of "a lion rampant grasping in the dexter two arrows point upwards in saltire and resting the sinister paw on a book erect," with the Latin motto *Heri docendum hodie implendum* ("Yesterday it had to be taught, today it has to be carried out"). The badge for Akrotiri—an airfield situated on a promontory and bordering a lake—is "a flamingo passant on a representation of water in base," with the motto *Acra semper acria* ("The peninsula is always eager").

Five Standards Awarded

THREE R.A.F. and two of the disbanded R.Aux.A.F. squadrons have been awarded Standards by the Queen. They are Nos. 40, 48 and 65 Sqns., R.A.F., all of which completed 25 years' service on April 1 this year; and the former Nos. 500 (County of Kent) and 604 (County of Middlesex) Sqns., R.Aux.A.F., which also completed 25 years' service before their disbandment on March 10.

No. 40 (now linked with No. 50 Sqn., Bomber Command, and re-named No. 50/40 Sqn.) operates Canberras from Upwood and is commanded by W/C. E. P. Landon; No. 48 is based at Changi, Singapore, and is at present (under the command of S/L. L. Hague) re-equipping with Hastings; No. 65, at Duxford, has Hunter F.6s and is commanded by S/L. G. M. Hermitage.

Nos. 500 and 604 were formed respectively in 1931 and 1930. Both were disbanded during 1945 but re-formed the following year to serve in the R.Aux.A.F. No. 604 operated in the Battle of Britain and later became famous for the Cunningham and Rawnsley night-fighter victories.

No. 206 Sqn. History

AN illustrated account of its history is being compiled by No. 206 Squadron, which was recently awarded the Aird Whyte Trophy—presented by the A.O.C.-in-C. Coastal Command, Air Marshal Sir Bryan V. Reynolds, to the commanding officer (W/C. J. E. Preston) at a ceremony at St. Eval on September 14. Any former members of No. 206 (or of its predecessor, No. 6 Sqn., R.N.A.S.) who have relevant material—personal experiences, photographs, etc.—which they would like to contribute are asked to send it to the squadron adjutant at R.A.F. St. Eval, Wadebridge, Cornwall. All such material, states the squadron, will be carefully handled and returned.

Henlow Souvenir

A COPY of the Army Order of May 1, 1912—reproducing the Royal Warrant which approved the formation of the R.F.C.—has been presented to the R.A.F. Technical College, Henlow, by Mr. W. G. Turner on his retirement after 45 years' continuous air force service. The order, which is framed and has been hung in the senior cadet mess at Henlow, refers to flying pay for ascents in "airships and kites" and reminds applicants for flying duties that each candidate must give his weight and state "whether he is a good map reader and field sketcher."

Mr. Turner, now 66, served first with the R.F.C. (joining No. 3 Sqn. at Larkhill on Salisbury Plain in June 1912) then with the R.A.F. and finally—for the last 18 years—as a civilian on the staff at Henlow. One of his memories of Salisbury Plain days is of seeing the first publicly observed spin, from which Lt. W. Parke and his observer successfully recovered in the Avro cabin biplane during the 1912 military trials of various aircraft.

No. 79 (F.R.) Sqn. Reunion

AN informal aircrew-reunion of No. 79 (F.R.) Sqn. will be held on Saturday, November 16, at the R.A.F. Club, 128 Piccadilly, London, W.1. Those wishing to attend should contact F/O. J. Munro at R.A.F. Compton Basset, Wilts.

IN BRIEF

Pioneers of No. 215 Sqn., Hastings from Nos. 24 and 99 Sqns. and Beverleys from Nos. 30 and 47 Sqns. took part last week in Exercise Long Hop, carried out by No. 24 Independent Brigade Group. About 55 sorties were flown by the Beverleys and Hastings during the three days of the exercise.

* * * * *

The general secretary of the Royal Air Forces Association, Mr. G. R. Boak, is to attend the annual conference of the World Veterans' Federation in West Berlin from October 28 to November 1.

No. 5 Sqn. (whose history is continued on pp. 642-6 of this issue) was disbanded at Wunstorf on October 12. Below, left, A.V.-M. H. J. Kirkpatrick takes the salute at a final parade; and right, the Standard is sent away to be laid up in the Church of St. Boniface at H.Q., 2nd T.A.F.

"Flight" photographs

NATO Courses on Guided Missiles

Foreign Service and Civilian Students at Cranfield

IN July of last year the Minister of Supply announced that the Government had undertaken to provide instructional courses in the basic principles of guided-missile design and operation for military and civilian scientists from other NATO countries. The courses were to be provided by the College of Aeronautics at Cranfield, and entrants were to be of the standard required for a good honours degree in a British university. By August the College authorities had worked out a rough syllabus and had invited entries for the first course, 30 of which—from seven NATO countries—were accepted; and during September the syllabus was substantially remodelled in view of the experience and qualifications of the students selected. In early October a start was made. The course consisted of three ten-week terms, and students were required to make a general study of aerodynamics, design, electrical engineering, propulsion, mathematics of trajectories, and flight. They were also required to select two of the first four subjects for specializations, with laboratory periods each week.

In spite of the haste with which the course was introduced, it proved extremely successful; and a similar one, with 24 entries, has just begun at Cranfield. One student, Major Romano of Italy, has attended both, specializing differently each time. Additions to the syllabus this year include lectures on the mathematics of assessment, and on production and economics; and guidance and control have been made separate specialization subjects. The course is run entirely separately from the normal Cranfield Diploma Course, although, naturally, subject material and lectures overlap to some extent.

No students from Canada or the U.S.A. have as yet attended, probably because a similar facility has been available at Michigan University since 1946; nor have there been any British personnel, although it is intended to provide vacancies for them in future (there is no comparable course for civilians in this country at the moment, but the R.A.F. hold one at Henlow and the Army another at Shrivenham). The foreign students on the first two courses—for whom a good knowledge of English has been mandatory—have been about two-thirds Service and one-third civilian. In general, the former subsequently receive appointments in Ministerial requirements departments, or join establishments similar to the R.A.E.; the latter, for the most part, return to the industrial firms which sent them on the course.

Any course on guided weapons must at once come up against the problem of security, but this has proved to be only a minor difficulty in the Cranfield case. The syllabus is in fact cleared at "confidential" level to give it added scope and interest, but the real point is that the various techniques of guided-weapon design are based on well-established principles, which can be combined and modified in an almost infinite number of ways; and success depends on forging a team that is capable of relating and blending the various factors in the most intelligent manner. Happy compromise is the essence of the business, and this entails each man knowing not only his own pet subject but also having a working knowledge, sufficient for constructive discussion and suggestions, of the other sciences which together enable a successful weapons system to be created. This is the real basis of the NATO course, and reference to the realities of actual weapons can therefore be cut to a security-safe level without losing the point of the instruction. The lecturers are given access to much secret information about actual hardware, but this is as much to show them what not to overstress as to provide background to their talks.

Another point about the staff is that they make great efforts to keep up-to-date with the latest developments, both by visiting factories and establishments during term and by actually working in such places during parts of their vacations. Extra permanent staff have also been signed on, so that it is now hoped to cater for up to 45 students on each course in future years. Finally, industry has co-operated wholeheartedly by providing occasional visiting lecturers and by loaning equipment. The College stresses that without such assistance by the manufacturers the course could not have proved such a success.

Turning now to more detail of the personnel and work of the various departments, the Principal of the College is Prof. A. J. Murphy, M.Sc., F.I.M., and the chairman of the NATO course is Prof. G. A. Whitfield, B.Sc., F.Inst.P., A.F.R.Ae.S., A.M.I.E.E., who also heads the Department of Aircraft Electrical Engineering. This is appropriate, for the course includes instruction on G.W. guidance and control, simulators, servo-mechanisms, instruments and overall systems, as well as a review of the background knowledge essential for an understanding of these subjects.

In the Aerodynamics Department, of which the head is Prof. J. A. J. Bennett, B.Sc., M.A., Ph.D., D.Sc., D.I.C., F.Inst.P., M.I.Mech.E., F.R.Ae.S., A.F.I.Ae.S., a series of 30 lectures of a relatively non-mathematical nature is given, designed to indicate the problems the specialists must meet—such as those concerned with low aspect-ratios, high incidence, heat transfer and cruciform structures. The specialists then cover the subjects in much greater detail. In the current session, for example, they will test a typical G.W. configuration at subsonic speed in the 8ft × 6ft wind tunnel, utilize a shock-tube to investigate aerodynamic heating and—in conjunction with the Department of Aircraft Design—participate in a project for the theoretical design of a missile, to a specification laid down by the various departments. (Last year the "G.M.56" was given a slant range of 30,000 yd, and was to reach Mach 2.0 to 2.5 whilst attacking a single aircraft flying at M = 0.9 at up to 60,000ft.)

The Department of Aircraft Design, headed by Prof. W. S. Hemp, M.A., F.R.Ae.S., gives a general and two specialist courses in the subject: practical work comprises demonstrations in the first term, and for the remainder of the time is concerned with the design project. The Department has a collection of actual and sectioned missiles for inspection and handling, as well as a comprehensive set of scaled models of all security-cleared weapons that have been made anywhere in the world to date. The Department of Flight, of which W/C. C. G. B.McClure, A.F.C., B.A., A.R.Ae.S., is head, gives instruction on the flight trials of guided weapons, on range facilities, and on instrumentation and telemetry. Laboratory equipment includes examples of the three current systems of telemetry, together with a kiné-theodolite and Doppler radio with which it is hoped to carry out a trajectory evaluation on a College aircraft. Finally, in the Department of Aircraft Propulsion there are, in addition to lectures, demonstrations of fuels and combustion systems; pump characteristics are tested; rocket motors (of 2,000 lb and 10 lb thrust) are run; ramjets are operated (in an airstream provided by a 2,000 h.p. motor); and visits are arranged to guided-missile manufacturers and to M.o.S. establishments engaged in missile work.

Further details of these NATO courses are available from the Warden, the College of Aeronautics, Cranfield, Bletchley, Bucks.

NEW PILOTS' RATING PROPOSED

PROPOSALS for a special clearance certificate for private pilots have been submitted by the Guild of Air Pilots and Air Navigators to the M.T.C.A. This would enable a pilot to enter or leave a controlled airspace in marginal weather conditions. Requirements would be 200 hours' flying time and satisfactory performance in an oral examination; resulting privileges would be (1) to allow the holder of a Private Pilot's or other Licence not endorsed with an Instrument Rating, to enter or leave a controlled airspace in marginal conditions (defined as below I.M.C. but not less than one nautical mile visibility), and (2) permit the right to depart at night from an aerodrome in a controlled airspace, provided the pilot has a night rating. The certificate would be valid for visual flying only. The Guild expresses its opinion that such a certificate would be valuable, but that any reduction in the standard of the Instrument Rating would not be favoured by the Guild.

The proposed certificate, it is said, would give guidance to air traffic control officers as to the ability of private pilots to fly under the above conditions.

FORTHCOMING EVENTS

Oct. 30. Kronfeld Club: "B.E.A.," by P. W. Brooks, B.Sc.(Eng.), A.C.G.I., A.F.R.Ae.S.

Oct. 31. G.A.P.A.N.: "British Aircraft: Some Designers' Problems," by D. L. Brown, A.M.I.C.E., M.I.Mech.E., M.I.Gas.E., A.F.R.Ae.S.

Nov. 2. British Interplanetary Society: "Conditions for Life," by Dr. J. W. S. Pringle, M.B.E., F.R.S.

Nov. 6. Kronfeld Club: Talk by Phillip Wills.

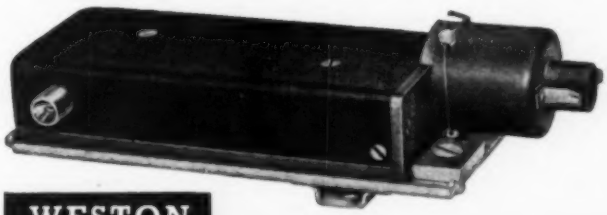
Nov. 7. R.Ae.S.: Graduates and Students Section: "Background to Aircraft Specifications," by K. W. Clark.

Nov. 8. Helicopter Association: Discussion on "The Problems Relating to the Installation and Operation of Radio Equipment in Helicopters." Introduced by D. W. Griffiths, M.S.I.A.E.

Nov. 12. R.Ae.S.: Section Lecture: "Some Problems of Stability and Control," by H. H. B. M. Thomas, A.F.R.Ae.S.

R.Ae.S. Branch Lectures (to Nov. 13):—

Oct. 29, *Boscombe Down*, "Review of the Future Prospects of Fleet Aviation," by Rear Adml. D. R. F. Cambell. Oct. 30, *Southampton*, "Engineering Education," by Prof. A. R. Collar. Nov. 13, *London Airport*, Brains Trust.



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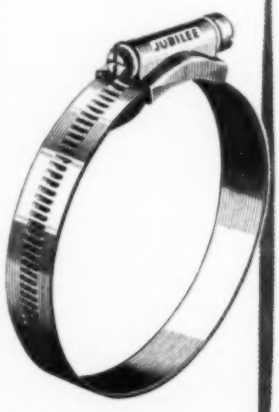

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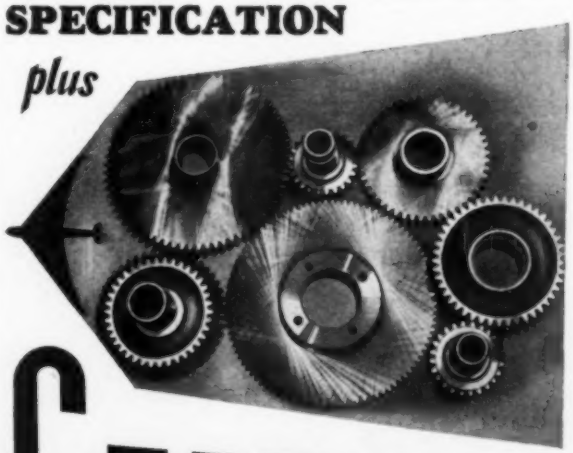

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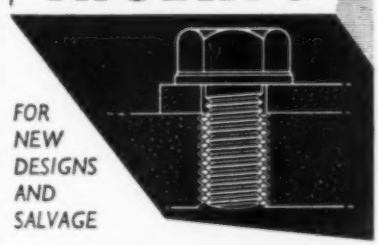

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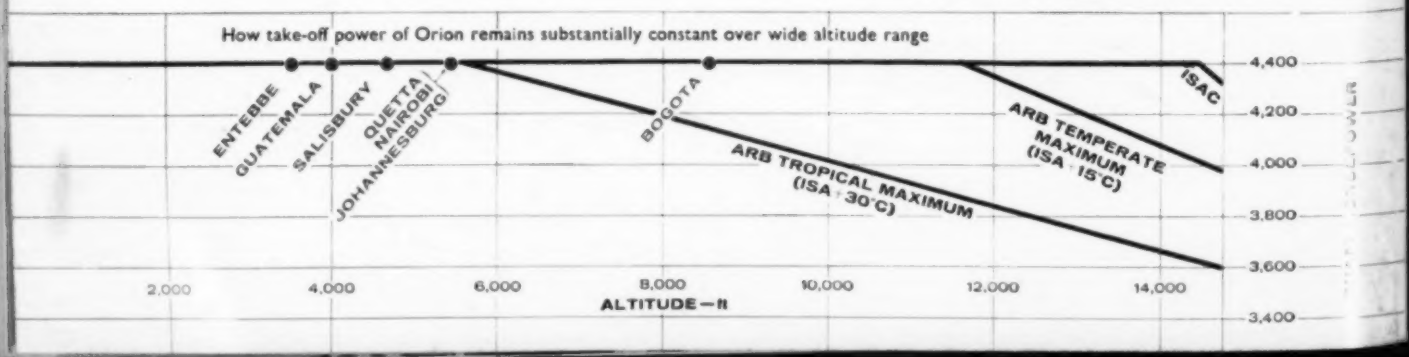
How take-off power of Orion remains substantially constant over wide altitude range